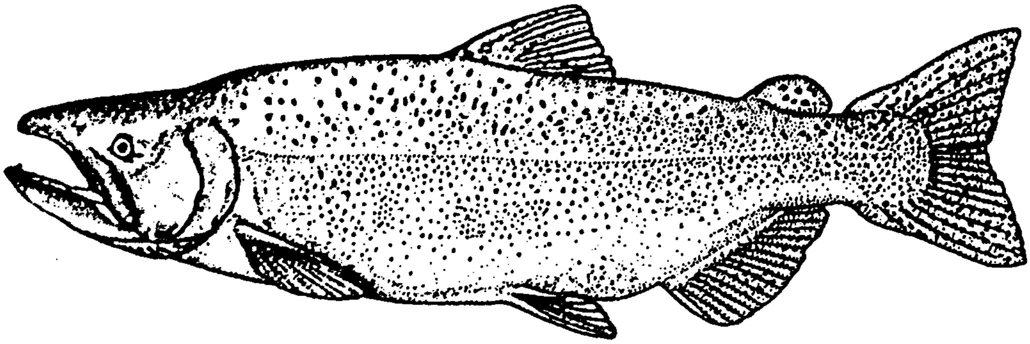
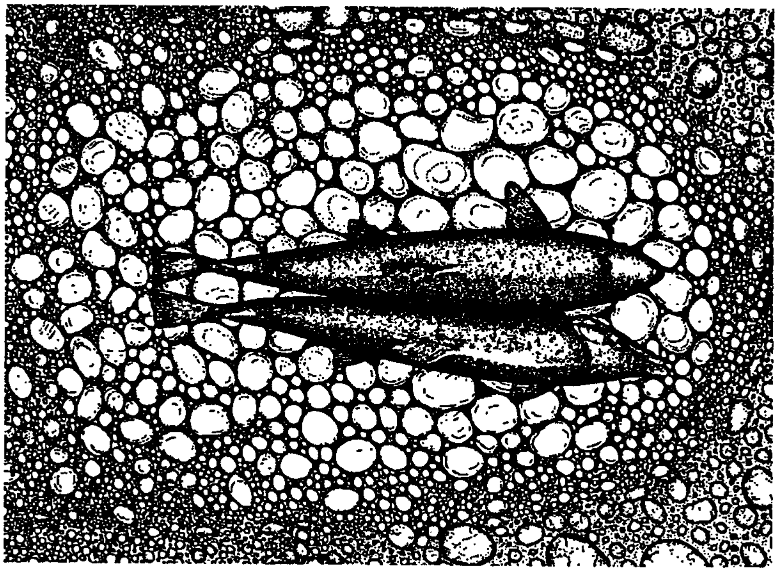
IDENTIFICATION OF THE INSTREAM FLOW REQUIREMENTS FOR FALL-RUN CHINOOK SALMON SPAWNING IN THE MERCED RIVER





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ANADROMOUS DOUBLING PLAN INSTREAM FLOW INVESTIGATIONS
MERCED RIVER FALL-RUN CHINOOK SPAWNING

PREFACE

The following is the final report for the U. S. Fish and Wildlife Service's investigations on the Merced River, part of the Anadromous Doubling Plan Instream Flow Investigations, a 5-year effort which began in February, 1995. Title 34, Section 3406(b)(1)(B) of the Central Valley Project Improvement Act, P.L. 102-575, requires the Secretary of the Interior to determine instream flow needs for anadromous fish for all Central Valley Project controlled streams and rivers, based on recommendations of the U. S. Fish and Wildlife Service after consultation with the California Department of Fish and Game (CDFG). The purpose of these investigations is to provide scientific information to the U. S. Fish and Wildlife Service Central Valley Anadromous Fish Restoration Program to be used to develop such recommendations for Central Valley rivers.

To those who are interested, comments and information regarding this report are welcomed. Written comments or information can be submitted to:

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ACKNOWLEDGMENTS

The field work for this study was conducted by Jennifer Bull, Sean Gallagher, Mark Gard, Jeff Thomas and Rick Williams. The field work was greatly facilitated by Roger Guinee, Ted Selb, Bill Loudermilk and Clarence Mayotte's assistance in coordination and Lester Yamaguchi's assistance in identifying spawning areas and marking redds. Data analysis and report preparation were performed by Mark Gard, Sean Gallagher and Jeff Thomas. We would like to acknowledge the cooperation of the Western Stone Corporation, and the cooperation of the following landowners for permitting access: Red Carson, Chris Robinson and John Hardin. Finally, we greatly appreciated the hospitality of Mike Cozart and Dixie Hartman of the Merced River Fish Facility and the use of CDFG trailers during field work.

INTRODUCTION

In response to substantial declines in anadromous fish populations, the Central Valley Project Improvement Act requires the doubling of the natural production of anadromous fish stocks, including the four races of chinook salmon (fall, late-fall, winter, and spring runs), steelhead, and white and green sturgeon. For the Merced River, the Central Valley Project Improvement Act Anadromous Restoration Plan calls for October and November (during fall-run chinook salmon spawning) flows ranging from 250 cfs in critically dry years to 350 cfs in wet years (U. S. Fish and Wildlife Service 1995). In December 1994, the U. S. Fish and Wildlife Service prepared a study proposal to identify the instream flow requirements for anadromous fish in certain streams within the Central Valley of California, including the Merced River. The purpose of this study is to produce a model predicting the availability of physical habitat in the Merced River over a range of streamflows for spawning fall-run chinook salmon. The Physical Habitat Simulation (PHABSIM) component of the Instream Flow Incremental Methodology (IFIM) was used for this modeling. The results of this study are intended to supplement data collected by CDFG to produce comprehensive instream flow recommendations, to support or revise the flow recommendations above.

METHODS

Study Site Selection

Project scoping began in March 1996. Redd count data (Table 1) collected by CDFG from 1989 to 1991 and from 1993 to 1994 in the 10 miles of the Merced River below Crocker-Huffman Dam were ranked to identify areas consistently receiving the heaviest spawning use by fall-run chinook salmon. Staff, along with Lester Yamaguchi of CDFG (who performed the redd counts in 1994 and 1995), conducted field reconnaissance of the reach on July 2-3 at a streamflow of approximately 200 cfs to investigate the suitability of the 11 highest-ranked riffles for modeling. Based on Mr. Yamaguchi's recollections, we identified portions of each riffle receiving the heaviest spawning use. Access points, property ownership, recreational use, study site boundaries, and possible surveying complications were also investigated during this visit. Seven study sites were identified encompassing eight of the 11 riffles investigated, six covering a single riffle and one including two of the top ranked spawning riffles. One of the excluded riffles (ranked fifth) was located below a head control wing dam and is no longer useable for spawning because the spawning gravels were removed to rebuild the dam after high winter flows washed it out. Another riffle (ranked tenth) was not suitable for hydraulic modeling due to complex hydraulics and logistical problems in reaching the site. A third riffle (ranked eleventh) was inadvertently omitted from any study site because of confusion as to the location of this riffle, as identified on a CDFG map of the Merced River.

Table 1
Merced River Redd Count Data (from CDFG)

CDFG Riffle #	1989	1990	1991	1992	1993	1994	1995	1996
51	48	17	57	32	13	36	1	56
1	35	6	11	9	8	38	48	30
45	34	4	26	10	2	7	0	1
44	7	7	8	0	7	10	0	3
23	19	8	5	2	2	8	0	0
2	0	35	48	22	36	56	13	108
56	19	3	2	0	0	7	3	11
38	61	0	0	5	14	34	1	20
60	17	0	2	4	5	13	0	0
36	8	0	7	8	3	9	0	5
37	16	1	8	1	0	4	3	6
21	26	1	0	0	4	4	1	8
12	15	1	0	0	3	6	4	6
57	17	0	3	1	6	4	0	15
55	0	6	0	0	3	10	1	13
31	14	0	6	1	1	5	0	1
46	47	7	23	0	0	0	0	4
54	12	1	0	5	3	5	2	0
10	7	0	0	0	3	12	0	5
14	4	1	0	2	1	4	2	9
50	19	1	0	0	0	2	0	0
39	32	0	1	2	0	4	0	0
16	3	0	0	0	2	6	2	3
40	8	0	0	3	0	10	1	0
43	0	3	0	0	1	6	0	0
8	0	2	0	0	1	5	1	12
61	13	0	3	4	0	1	0	0
62	6	0	8	4	3	0	0	10
25	12	1	0	0	1	0	0	2
13	1	1	0	8	3	0	0	9
52	0	0	1	1	0	10	2	2
58	12	0	3	2	0	3	0	0
15	0	1	0	0	0	5	0	0
53	21	0	0	3	1	0	1	2
9	7	1	0	1	0	1	1	0
3	15	0	0	0	1	0	3	28

Data from 1992 through 1996 were from the peak spawning week.

Establishment of Study Sites

Transects were placed in the selected sites (Appendix A) across the optimal spawning areas using 9 mm diameter rebar driven into the ground and/or lag bolts placed in tree trunks on opposite sides of the river. Transect locations were based on substrate particle size (i.e., across areas which appeared to have substrates suitable for chinook salmon redd excavation) and hydraulic variability. The study sites, CDFG riffle number, and number of transects placed at each site are shown in Table 2. Permanent (primary) benchmarks were established at each site to be used as reference elevations during the course of the study. Additional secondary benchmarks (one to three per site) were also established to facilitate surveying over the length of each site and through riparian vegetation. The primary benchmarks were assigned an elevation of 100.00 feet. The secondary benchmark elevations were tied to the primary through differential leveling.

Table 2
Merced River Sites

Site Name	Riffle Number(s)	Number of Transects
Hatchery	1, 2	5
Big Bull Flat	38B,C&X	5
Red's Riffle	44	3
Barnowl Riffle	45	2
Robinson Riffle	51A&B	6
Sodbuster Riffle	56	3
Bull Frog Riffles	60A&B	4

Field Data Collection

Hydraulic and structural data collection, using the procedures outlined in Trihey and Wegner (1981), began in late July and was completed in October 1996. Lateral cell boundaries (measurement verticals) were established across each transect systematically or where significant differences in bed elevations, water velocity, or substrate composition were observed. At least 20 verticals were established across the wetted width with a goal of no more than 10 percent of total stream discharge passing through any one cell. Except in a few instances this goal was met. Data collected at each lateral cell boundary included bed elevation, mean water column velocity and substrate classification. Bed elevations for verticals on dry land, to points above bankfull discharge, were surveyed to the nearest 0.1 foot using differential leveling referenced to a benchmark. Water surface elevations (WSELs), also referenced to a benchmark, were surveyed to the nearest 0.01 foot. All surveying was done with a Sokkisha autolevel. Depths were measured to the nearest 0.1 foot with a top-setting wading rod. Bed elevations for verticals in the water were calculated by subtracting the measured water depth from the WSEL. Mean water column velocities at each vertical were measured at 0.6 of the total depth using a Price AA water velocity meter attached to the wading rod, equipped with a current meter digitizer. The dominant substrate particle size was described according to a modified Brusven index (Table 3) and recorded at the same time as velocities (or bed elevations for verticals on dry land) were measured for all transects.

Table 3
Merced River Substrate Codes

Substrate Category	Substrate Code
fines or > 75% embedded	0
gravel < 1"	1
1" - 2" gravel	2
2" - 4" gravel/cobble	3
4" - 6" cobble	4
6" - 8" cobble	5
substrate > 8"	6
aquatic vegetation	7

For all of the sites except the Hatchery site, WSELs were measured on all transects on August 5 to 7 at main-channel discharges ranging from 82 to 153 cfs. WSELs were measured on all transects on October 9, 10 and 22 at discharges ranging from 422 to 472 cfs, on October 15 and 16 at 1003 to 1154 cfs, and on October 23 at 225 to 297 cfs (see Appendix B for flows at which data were collected for each transect). Depths and velocities were measured for all transects at all sites except Hatchery and Big Bull Flat on August 5 to 7, and for all transects at all sites on October 9, 10 and 22. At the Sodbuster and Bullfrog sites, depths and velocities in cells near the river's edge were also measured on October 17 at a discharge of 1063 cfs. These measurements were used to compute Manning's n values for cells which were dry or barely inundated at the velocity calibration flow (422 to 472 cfs) for use during hydraulic calibration. Because of substantial diversions, discharges used in hydraulic calibration were computed from transect depth and velocity measurements[1]. Since the Hatchery and Big Bull Flat sites included transects in split channels, additional discharge measurements were made for each channel to develop an empirical relationship between split-channel discharges and main-channel discharges. Split channels were identified as left or right channels looking upstream.

Habitat Suitability Criteria (HSC) Data Collection

Habitat suitability criteria (HSC or HSI Curves) are used within PHABSIM to translate hydraulic and structural elements of rivers into indices of habitat quality (Bovee, 1994). While HSC developed from data collected from other river systems can be used in habitat modeling, it is most often desirable to develop site-specific criteria where possible (Bovee, 1986). Recognizing the need for site-specific HSC for Merced River fall-run chinook spawning, this task was undertaken as part of this investigation.

The primary habitat variables which are used to assess physical habitat suitability for spawning chinook salmon are water depth, velocity, and substrate composition (including embeddedness). Data relative to these variables were collected from 186 fall-run chinook salmon redds on October 12 through 14, 1996. Most of the data were collected from redds in the study sites, although five additional riffles within the study reach, identified by CDFG as having significant numbers of redds during the 1996 spawning season, were also sampled. Measurements were taken with a wading rod and a Price-AA velocity meter equipped with a current meter digitizer. All recently constructed redds (redds without periphyton) within a given spawning riffle which could be conclusively identified were measured. Depth and velocity data were collected two to four feet upstream of the pot which was assumed to have hydraulic conditions similar to the redd location prior to redd construction. Depth was recorded to the nearest 0.1 ft and mean water column velocity was recorded to the nearest 0.01 ft/s. Substrate was visually assessed, both at the depth/velocity measurement location (hereafter referred to as head) and in the tailspill (hereafter referred to as tail), for the dominant particle size range (e.g., range of 1-2"). Substrate embeddedness data were not collected because the substrate adjacent to all of the redds sampled was predominantly unembedded. Redd locations at the study sites were determined using standard horizontal surveying techniques and recorded. Merced River flows (measured at the Merced Irrigation District gage approximately one-half mile below Crocker-Huffman Dam) averaged 275 cfs during the sampling period. All data were entered into a spreadsheet for analysis and development of HSC (HSI Curves). The development methodology and the resulting HSC are discussed in a subsequent section of this report.

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[1] The only exception to this was for the Hatchery Site on October 15, where the discharges for the transects were computed by subtracting diversions for the Merced River Fish Facility and the Calaveras Trout Farm, and flows measured in minor unmodeled side channels, from the flow recorded at the Merced Irrigation District gage, which is located downstream of the return flows from these diversions and side channels.

All data were compiled and checked before entry into PHABSIM data decks. A separate deck was constructed for each study site. In addition, a separate deck was constructed for each split channel at the Hatchery and Big Bull Flat sites. The completed decks were then examined using the *CKI4* program to check for data entry errors. The stage of zero flow (SZF), an important parameter used in calibrating the stage-discharge relationship, was determined for each transect and entered. In habitat types without backwater effects (e.g., riffles and runs), this value generally represents the lowest point in the streambed across a transect. However, if a transect directly upstream contains a lower bed elevation than the adjacent downstream transect, the SZF for the downstream transect applies to both. Calibration flows in the data decks (Appendix B) were the average of discharges calculated from depth and velocity measurements on all transects (not separated by a diversion or return flow), for which measurements were taken during a given period of steady flow[2]. Linear regression was used to develop relationships between the streamflow in each split channel of the Hatchery and Big Bull Flat sites and the total river flow. These regression equations were used to estimate streamflow in each split channel of the Hatchery and Big Bull Flat sites for each of the simulated total river flows.

The first step in the calibration procedure was to determine the best approach for WSEL simulation. Initially, the *IFG4* hydraulic model (Milhous *et al.*, 1989) was run on each deck to compare predicted and measured WSELs. This model produces a stage-discharge relationship using a log-log linear rating curve calculated from at least three sets of measurements taken at different flows. Besides *IFG4*, two other hydraulic models are available in PHABSIM to predict stage-discharge relationships. These models are: 1) *MANSQ*, which operates under the assumption that the condition of the channel and the nature of the streambed controls WSELs; and 2) *WSP*, the water surface profile model, which calculates the energy loss between transects to determine WSELs. *MANSQ*, like *IFG4*, evaluates each transect independently. *WSP* must, by nature, link at least two adjacent transects. *IFG4*, the most versatile of these models, is considered to have worked well if the following standards are met: 1) the beta value (a measure of the change in channel roughness with changes in streamflow) is between 2.0 and 4.5; 2) the mean error in calculated versus given discharges is less than 10%; 3) there is no more than a 25% difference for any calculated versus given discharge; and 4) there is no more than a 0.1 foot difference between measured and simulated WSELs. For a majority of the transects, *IFG4* met the above standards (Appendix B), the exceptions being Big Bull Flat Transect 1, the left split

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[2] During the course of the study it was recognized that streamflow could fluctuate significantly in a relatively short time period due to upstream irrigation diversions/returns or wing dam reconstruction. Because of this, temporary staff gages were placed on-site and monitored frequently to determine which transect discharges could be averaged to obtain calibration streamflows. The five sites furthest downstream (Robinson Ranch, Red's Riffle, Barnowl Riffle, Sodbuster Riffle and Bullfrog Riffles) were not separated by diversions or return flows.

channel of Big Bull Flat Transects 4 and 5, Robinson Riffle Transect 1, Sodbuster Riffle Transect 2, Red's Riffle Transect 3, and Hatchery Site Transects 3, 4 (right split channel) and 5. *MANSQ* worked successfully for Big Bull Flat Transect 1, Robinson Riffle Transect 1, Sodbuster Riffle Transect 2 and Red's Riffle Transect 3, meeting the latter three above standards (Appendix B)[3]. *WSP* worked successfully for the right split channel of Hatchery Transect 4, with the last standard being met[4].

For the Hatchery site Transects 3 and 5, initial calibration using *IFG4* resulted in a greater than 0.10 foot difference between measured and predicted water surface elevations. Boulder weirs located a short distance downstream of both of these transects could have increased the SZF for these transects above the low point on the cross-section. In fact, surveying of the boulder weir below the left split channel of Transect 3 indicated that the SZF was 0.3 feet above the low point on that cross-section. Accordingly, the SZF was raised 0.3 feet for the left channel of Transect 3 and 0.4 feet for Transect 5 and the right channel of Transect 3 (assuming that the boulder weirs below these cross-sections had a similar effect on their SZFs). These adjustments resulted in the latter three standards being met but the beta coefficient values were less than 2.0. In addition, the Velocity Adjustment Factors (VAF) for these transects (Appendix C) decreased with increasing flow, with the largest decrease associated with the smallest beta coefficient value. VAFs typically increase monotonically with increasing flows as higher flows produce higher water velocities. The model, in mass balancing, was obviously decreasing water velocities at high flows so that the known discharge would pass through the increased cross-sectional area. We concluded that both of these phenomena were caused by channel characteristics which form hydraulic controls at some flows but not at others (compound controls), thus affecting upstream water elevations. Specifically, at lower flows the channel at these transects controlled the water surface elevations, while at higher flows the water surface elevations were controlled by the boulder weirs. In support of this conclusion, the beta values decreased when the SZFs were raised. Accordingly, the performance of *IFG4* for these two transects was considered adequate despite the beta coefficient standard not being met.

For the left split channel of Big Bull Flat Transects 4 and 5, the use of either *IFG4* or *MANSQ* result in predicted water surface elevations that differed from measured elevations by more than 0.10 feet using all four stage-discharge pairs. Further, *WSP* could not be applied because we were unable to develop a stage-discharge relationship for the portion of Transect 3 which

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[3] The first standard is not applicable to *MANSQ*, although having the beta value parameter used by *MANSQ* within the range of 0 to 0.5 (as was the case with all four of these transects, as shown in Appendix B), is an analogous standard for *MANSQ*.

[4] The other standards are not applicable to *WSP*. However, the Manning's n value used in calibrating this transect fell within the acceptable range (0.04 - 0.07), and there was a negative log-log relationship between the reach multiplier and flow (another indication of acceptable *WSP* calibration).

received flow from the left split channel. Examination of log-log plots of flow versus water surface elevation minus SZF indicated that at lower flows (up to 58 cfs in the left split channel, corresponding to 500 cfs in the main channel), the water surface elevations in the left split channel were controlled by conditions in the channel, but at higher flows were elevated due to backwater effects from the main channel. Accordingly, we concluded that the hydraulics in the left split channel could only be modeled up to a 500 cfs main channel flow. Using the three lower stage-discharge pairs, *IFG4* produced simulated water surface elevations within 0.10 feet of those measured and less than a 25% difference for the calculated versus given discharge for Transect 4. All of the standards were met for Transect 5. However, the mean error for Transect 4 was greater than 10% and the beta coefficient was greater than 4.5. The large mean error was most likely due to inaccuracy in flow measurement - despite having verticals spaced only 1 foot apart, up to 35% of the flow in this side channel went through one cell. Normally, the values of these parameters would not be acceptable, but because there was very little spawning habitat in the left split channel, this calibration was accepted for the hydraulic modeling. No redds were observed in the left split channel during the collection of habitat suitability criteria data.

Velocity calibration is the final step in the preparation of the hydraulic models for use in habitat simulation. An *IFG4* input deck was prepared for each study site[5], using the 422 to 472 cfs velocity set[6]. Each of these decks contained QARD flows (the flows to be simulated) from 200 to 700 cfs except the left split channel at Big Bull Flat which only went to 500 cfs for reasons noted above. For sites/split channels in which models other than *IFG4* were used, the WSELs simulated for these flows after calibration were entered on WSEL lines and IOC option 8 was enabled (this option instructs the program to use entered WSELs for velocity simulations rather than those derived running *IFG4*). *IFG4* was run on each deck, VAFs were examined for all of the simulated flows, and velocity statistics were computed for the lowest and highest flows and the flow for which there was a velocity set (Appendix C). The only transects that deviated from the expected pattern of VAFs were Hatchery Transects 3, 4 and 5 (for the reason discussed above), Sodbuster Transect 3 and Bullfrog Transects 1 and 3; the VAF patterns for the latter three transects did not differ significantly from the expected pattern. In addition, the VAF values (ranging from 0.435 to 1.233) were all within an acceptable range and the velocity statistics were acceptable.

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[5] As was previously mentioned, a separate deck was also constructed for each split channel within the Hatchery and Big Bull Flat sites.

[6] The 82 to 153 cfs velocity set was not used for velocity calibration since it fell below the range of flows being simulated.

Eight sets of HSC (HSI Curves) were used in this study - five from Merced River data, two from Stanislaus River data, and one Tuolumne River HSC set (Figures 1 through 3, Appendix D).

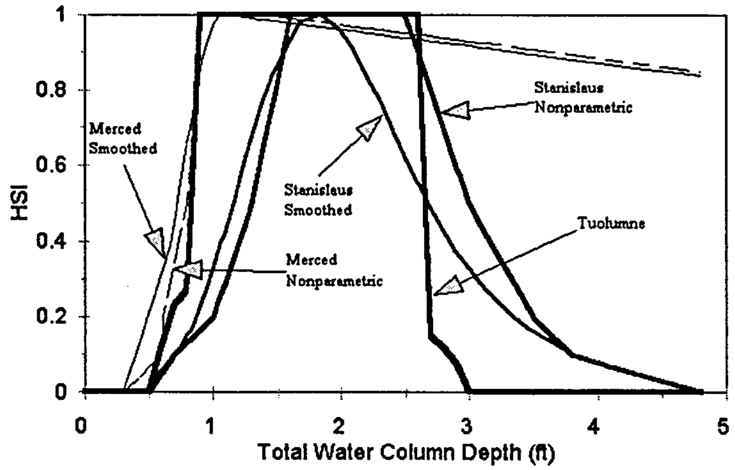

Figure 1. Fall-run Chinook Salmon HSI Curves for Depth

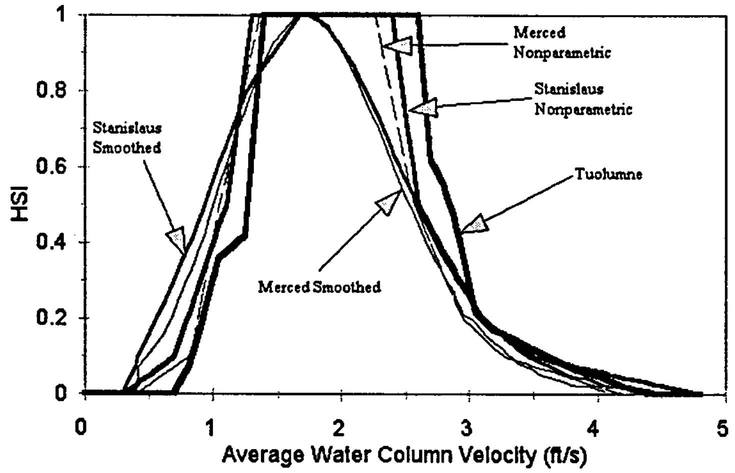

Figure 2. Fall-run Chinook Salmon HSI Curves for Velocity

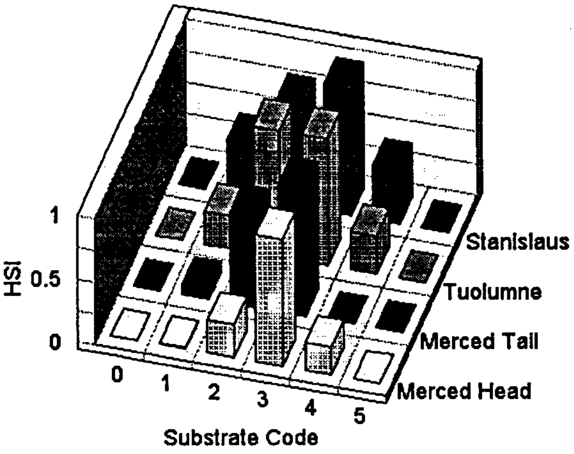

Figure 3. Fall-run Chinook Salmon HSI Curves for Substrate

The five sets of Merced River HSC were site-specific criteria, developed as follows. Using the data collected and entered into a spreadsheet, frequency distributions were calculated for depth and velocity and input into the PHABSIM suitability index curve development program (CURVE). The HSI curves were then computed using exponential smoothing. The curves generated were exported into a spreadsheet and modified by truncating at the lower end, so that the next depth or velocity value below the lowest observed value had a SI value of zero; and eliminating points not needed to capture the basic shape of the curves. Hereafter, these curves will be referred to as smoothed curves.

A second set of depth and velocity criteria (hereafter referred to as nonparametric) were developed from the Merced River redd data directly in the spreadsheet using the nonparametric tolerance limits method described by Bovee (1986). Specifically, depths and velocities within the middle 50% of the distribution of redd measurements were assigned suitabilities of 1.0. In addition, HSI values of 0.5, 0.2, and 0.1 were assigned to the depths and velocities at, respectively, 75%, 90%, and 95% of the distribution of redd measurements, while depths and velocities which were outside of the range of redd measurements were assigned a suitability of 0.0.

Substrate criteria were developed for the head and tail substrate data by: 1) determining the number of redds with each substrate code (Table 3); 2) calculating the proportion of redds with each substrate code (number of redds with each substrate code divided by total number of redds); and 3) calculating the HSI value for each substrate code by dividing the proportion of redds in that substrate code by the proportion of redds with the most frequent substrate code.

Both the initial smoothed and nonparametric Merced HSC showed suitability rapidly decreasing for depths greater than 1 foot. This effect was likely due to the low availability of deeper water in the Merced River with suitable velocities and substrates, rather than a selection by the salmon of only shallow depths for spawning. The following method was used to correct both the smoothed and nonparametric Merced depth criteria for the low availability of deeper water with suitable velocities and substrates. Based on the distribution of velocity and substrate redd data, we concluded that suitable velocities were between 1 and 2.5 ft/s, while suitable substrates were 2-4 inches in diameter (substrate code 3). A series of HSC sets were constructed where: 1) each set held velocity and substrate HSI values at 1.0 for the velocity and substrate range noted above with all other velocities and substrates assigned a value of 0.0; and 2) each set assigned a different 0.5-foot depth increment an HSI value of 1.0 for depths between 1.0 and 4.0 feet deep, with the other 0.5 foot increments and depths less than 1.0 foot and greater than 4.0 feet given a value of 0.0 (e.g., 1.0-1.5' depth HSI value equal 1.0, <1.0' and >1.5' depths HSI value equals 0.0 for set #1, etc.). Thus, six sets of HSC were constructed differing only in the suitabilities assigned for optimum depth ranges. Each HSC set was run through the *HABTAE* program using the output of the calibrated hydraulic decks for all of the study sites, with the resulting habitat output combined in a spreadsheet to determine the available river area with suitable velocities and substrates for the 0.5-foot depth increments from 1 to 4 feet. The redd data were used to determine the number of redds in each of the above depth increments to assess use. Relative availability and use were then computed by dividing the availability and use for each depth increment by the largest availability or use, thus scaling both measures to have a maximum value of 1.0. Linear regressions of relative availability and use versus the midpoint of the depth increments (i.e., 1.25' for 1-1.5' depth increment) were used to remove noise from the data and produce linearized values of relative availability and use at the midpoints of the depth increments. The results of the regressions showed that availability dropped with increasing depth, but not quite as quickly as use. For the range of depths where the regression equations predicted positive relative use and availability, linearized use was divided by linearized availability, and the resulting ratios were scaled so that the maximum ratio was 1.0. A third linear regression of the scaled ratios versus the midpoint of the depth increments was used to determine the depth at which the scaled ratios reached zero. The result of this regression was that the scaled ratio reached zero at 24 feet; thus, the depth criteria were modified to have a linear decrease in suitability from 1.0 for the highest depth in the original criteria which had a suitability of 1.0, to a suitability of 0.0 at 24 feet.

Based on this analysis, four sets of Merced River criteria were derived with each combination of head and tail substrate criteria, and smoothed and nonparametric depth (using the above correction for depth availability) and velocity criteria (Appendix D, pp. 44-46). A fifth Merced River HSC set was also used applying the original smoothed depth criteria (not corrected for depth availability), the smoothed velocity criteria and the tail substrate criteria (Appendix D, p. 49) to show the effects of the above correction for depth availability. We believe that the HSI values in this HSC set are largely an artifact of the low availability of deeper water with suitable velocities and substrates during HSC data collection and results derived from its use should be evaluated considering this.

Habitat preference criteria previously developed for the Stanislaus River (Aceituno, 1990) were not used because they were developed dividing use by availability; this method of correcting for availability is no longer recommended (Bovee, 1994). Instead, the original data used to develop these criteria were utilized to generate both smoothed and nonparametric HSC following the above techniques, with the following exceptions: 1) only one set of substrate criteria was developed because substrate data were only collected for one location for each redd; and 2) correction for depth availability with suitable velocities and substrates was not made. Tuolumne River HSC from U.S. Fish and Wildlife Service (1994) were modified for use in this study by converting the substrate codes to the codes used in this study.

HSC Transferability

The procedure described by Thomas and Bovee (1993) was used to determine which of the eight HSC sets in Appendix D were transferable to the Merced River. The procedure employs two one-sided χ^2 tests (Conover, 1971) using counts of occupied and unoccupied cells in each of three suitability classifications (optimum, useable and unsuitable) to determine if there is non-random selection for optimum habitat over useable habitat, and for suitable (optimum plus useable) over unsuitable habitat. Two null hypotheses are tested: 1) Optimum cells will be occupied in the same proportion as useable cells; and 2) Suitable cells will be occupied in the same proportion as unsuitable cells. For a set of HSC to be considered transferable, both null hypotheses must be rejected at the 0.05 level of significance.

Suitability classifications for depth, mean water column velocity, and substrate for each HSC set were determined as follows. For the three nonparametric sets, the optimum range for a variable was defined as the interval encompassing the central 50% of the measurements taken on redds (corresponding to an HSI value of 1.0). The suitable range for a variable was defined as the interval containing the central 95% (corresponding to HSI values greater than or equal to 0.1). Thus, the useable range for a variable encompassed the interval between the central 95 and 50 percent of the measured conditions (corresponding to HSI values between 0.1 and 1.0). The unsuitable range for a variable was outside of the central 95%, corresponding to HSI values less than 0.1. For the five sets of continuous (smoothed) HSC, the optimum range for each variable corresponded to HSI values greater than or equal to 0.75[7], useable corresponded to HSI values between 0.1 and 0.75, and unsuitable corresponded to HSI values less than 0.1. The depth, velocity, and substrate suitability ranges are illustrated in Figures 4 through 6.

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[7]This optimum range was selected after comparing counts derived using different optimum ranges from 0.65 to 0.85 (in 0.05 increments) to determine which range resulted in count totals closest to those derived using the nonparametric HSC.

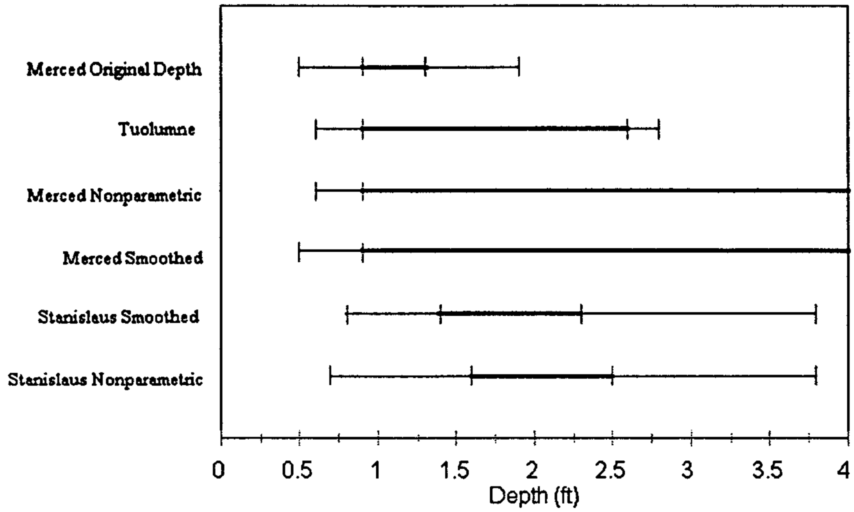

Figure 4. Optimum (wide line) and useable (thin line) ranges of depth HSC tested against observations of spawning chinook salmon in the Merced River.

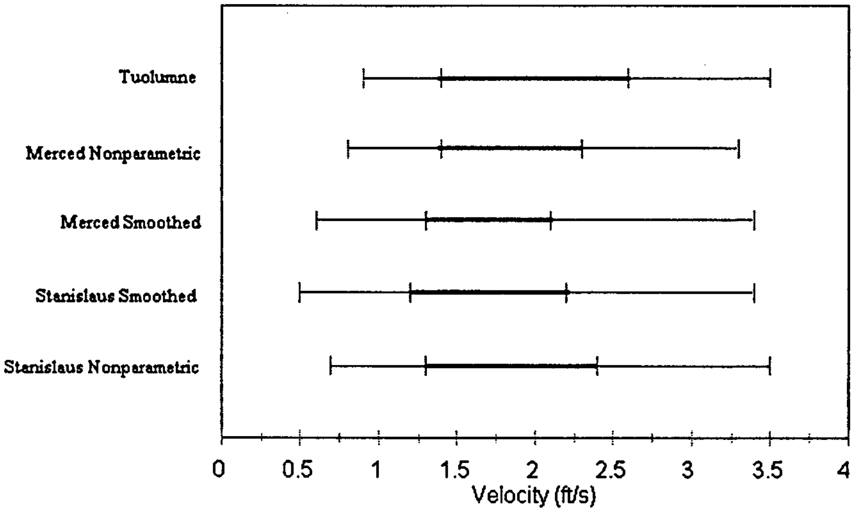

Figure 5. Optimum (wide line) and useable (thin line) ranges of velocity HSC tested against observations of spawning chinook salmon in the Merced River.

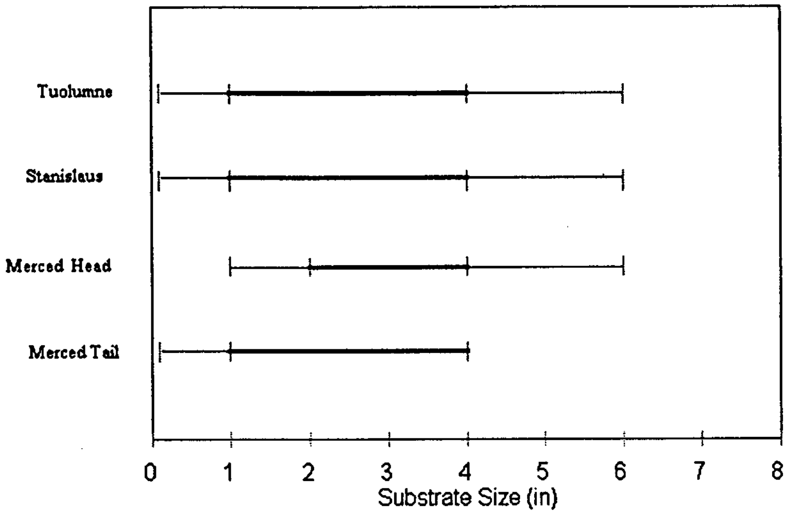

Figure 6. Optimum (wide line) and useable (thin line) ranges of substrate HSC tested against observations of spawning chinook salmon in the Merced River.

The test procedure requires a minimum of 55 occupied and 200 unoccupied cells to avoid either the erroneous acceptance of non-transferable HSC or rejection of transferable HSC (Thomas and Bovee, 1993). As previously mentioned, HSC data were collected from 186 redds on the Merced River in 1996. Of this total, 156 redds were found within the seven study sites used in the habitat modeling. The locations of these redds, to be used as the occupied data set, were surveyed and mapped in relation to the established transects. The *IFG4* hydraulic model was used to simulate cell-by-cell depths and velocities at the main-channel flow present during collection of the redd data at each respective site (200 to 275 cfs). To derive an unoccupied data set, this output was entered into a spreadsheet along with the substrate classification for each cell. Using the redd survey data, the cells which contained redds were identified and deleted from the data set. Also deleted were cells adjacent to occupied cells, and cells with depths less than 0.4 foot[8]. From the remaining unoccupied cells, 50 were randomly selected from each site (350 total cells) to use in the transferability test.

For each HSC set tested, composite suitabilities were calculated for each cell. The composite

[8] Cells adjacent to occupied cells were eliminated to take into account redd defense areas and horizontal surveying error. Cells with depths less than 0.4 feet were eliminated to increase the statistical power of the test.

suitability for a cell was classified as optimum if the individual suitabilities for depth, velocity, and substrate were all optimum. If the suitability for any variable was unsuitable, the composite suitability for the cell was classified as unsuitable. A cell was classified as useable if any or all the variables for the cell fell into the useable category. Data from all sites were combined to obtain counts of occupied and unoccupied cells of unsuitable, useable, or optimum composite suitability. Suitable counts were obtained by combining the optimum and useable counts. The counts were cross classified in two 2 x 2 contingency tables: one to test suitable versus unsuitable classifications and one to test optimum versus useable classifications. Test statistics were then calculated from each table using the test statistic for one-sided χ^2 tests given as

$$T = [N^{0.5}(ad-bc)]/[(a+b)(c+d)(a+c)(b+d)]^{0.5}$$

where a = number of occupied optimum (or suitable) cells; b = number of occupied useable (or unsuitable) cells; c = number of unoccupied optimum (or suitable) cells; d = number of unoccupied useable (or unsuitable) cells; and N = total number of cells. The null hypothesis is rejected at the 0.05 level of significance (indicating transferability) if $T \geq 1.6449$.

The results of the transferability tests for each set of HSC applied in the habitat modeling are presented in Table 4. The only set which failed to transfer were the nonparametric tolerance limits developed from Stanislaus River data. While the null hypothesis for the suitable/unsuitable test was rejected (T = 5.0478), the T value for the optimum/useable test (-0.2214) was far below the rejection level. Further investigation revealed that the cause of this failure was rooted in the nonparametric depth criteria. Comparing the optimum depth ranges from the Stanislaus Nonparametric HSC versus the Stanislaus Smoothed HSC (Figure 4), the

Table 4
Results of Transferability Tests

HSC Set	Optimum/ useable		Suitable/ unsuitable	
	T	P	T	P
Merced River Smoothed Tail	2.3793	0.0087	10.2078	< 0.0001
Merced River Smoothed Head	2.3396	0.0096	5.9357	< 0.0001
Merced River Nonparametric Tail	2.2857	0.0111	10.7114	< 0.0001
Merced River Nonparametric Head	1.9347	0.0265	6.5627	< 0.0001
Stanislaus River Smoothed	1.9805	0.0239	4.7521	< 0.0001
Stanislaus River Nonparametric	-0.2214	0.5876	5.0478	< 0.0001
Tuolumne River	5.8565	< 0.0001	5.1031	< 0.0001
Merced River Original Depth	2.0290	0.0212	11.0547	< 0.0001

Nonparametric optimum range encompasses depths from 1.6 to 2.5 feet while the Smoothed optimum range runs from 1.4 to 2.3 feet. The occupied data set from the Merced River (N=156) included 25 redds found in water 1.4 to 1.5 feet deep. The depth at these locations (cells) was classified as optimum using the Smoothed depth criteria but only useable using the Nonparametric depth criteria. Due to the limited availability of spawning habitat area in depths greater than 2.0 feet (only one redd was found in the study sites at a depth greater than this), the slightly deeper optimum range for the Nonparametric depth criteria did nothing to compensate for this classification discrepancy. The result was 14 more occupied optimal cells (and 14 fewer occupied useable cells) using the Smoothed HSC rather than the Nonparametric. Since the use of either the Smoothed or Nonparametric HSC from the Stanislaus River resulted in substantially fewer occupied optimum cells than the other HSC tested, this difference was fatal for the optimum/useable test. It also suggests that the habitat modeling results using even the Smoothed Stanislaus HSC should be considered with caution.

Habitat Simulation

After creating an input file with the HSC sets in Appendix D, habitat simulations were run using the *HABTAE* program to predict physical spawning habitat availability for chinook salmon in the Merced River at flows between 200 to 700 cfs in 50 cfs increments.

RESULTS

Weighted Usable Area (WUA) was computed using each criteria set cited above and is presented in Appendix E. Table 5 shows the correspondence between the titles of the HSC in Appendix D and the column headings in Appendix E. These results are presented by transect at the request of CDFG, the primary recipient of this report. The information contained herein will presumably be considered, along with empirical data which continues to be collected, in formulating instream flow recommendations that should benefit the fall chinook salmon population of the Merced River.

Table 5
HSC Curves versus WUA output

Appendix D HSC Title	Appendix E Column Heading
Merced River Smoothed Tail with Correction for Depth Availability	Merced Smoothed Tail
Merced River Smoothed Head with Correction for Depth Availability	Merced Smoothed Head
Merced River Nonparametric Tail with Correction for Depth Availability	Merced Nonpar Tail
Merced River Nonparametric Head with Correction for Depth Availability	Merced Nonpar Head
Stanislaus River Smoothed Use	Stanislaus Smoothed
Stanislaus River Nonparametric Use	Stanislaus Nonpar
Tuolumne River	Tuolumne
Merced River Smoothed Tail with Original Depths	Merced Original Depth

REFERENCES

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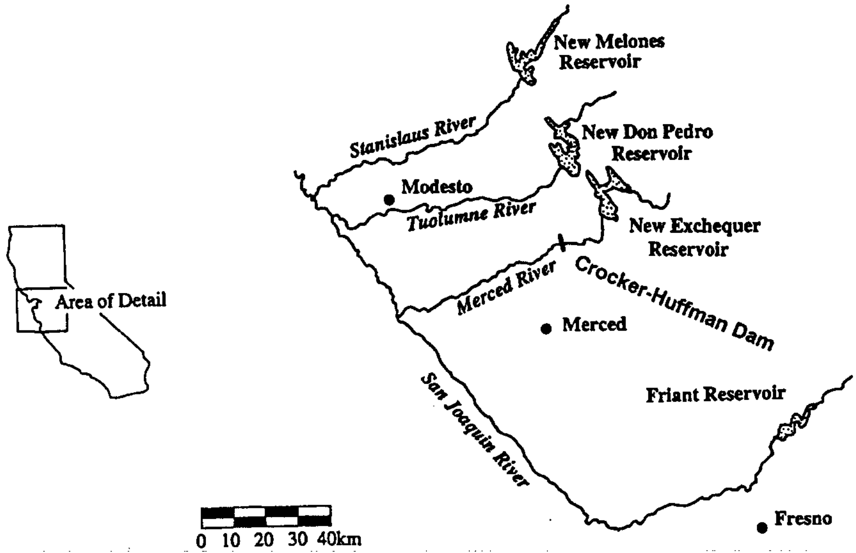
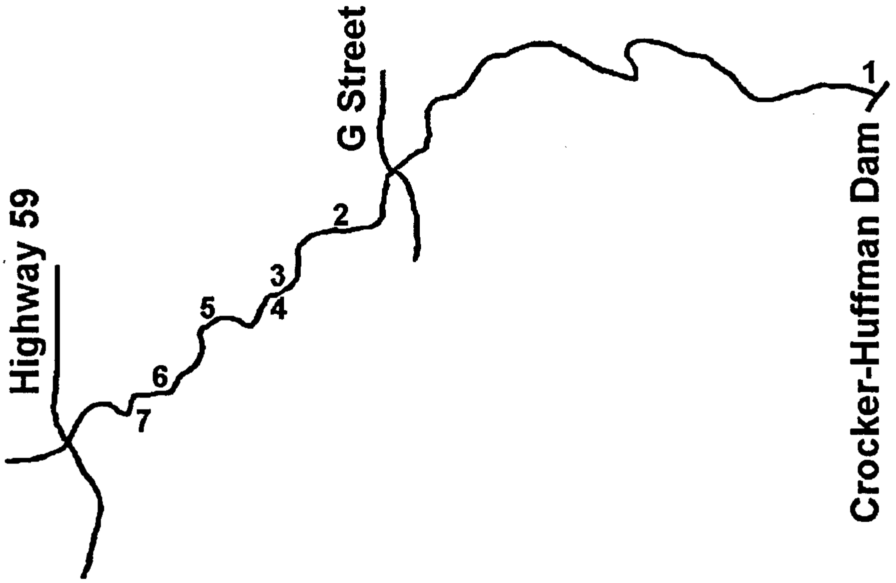
U. S. Fish and Wildlife Service. 1995. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volume 1. May 9, 1995. Prepared for the U. S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.

APPENDIX A
STUDY SITE AND TRANSECT LOCATIONS

Merced River Location

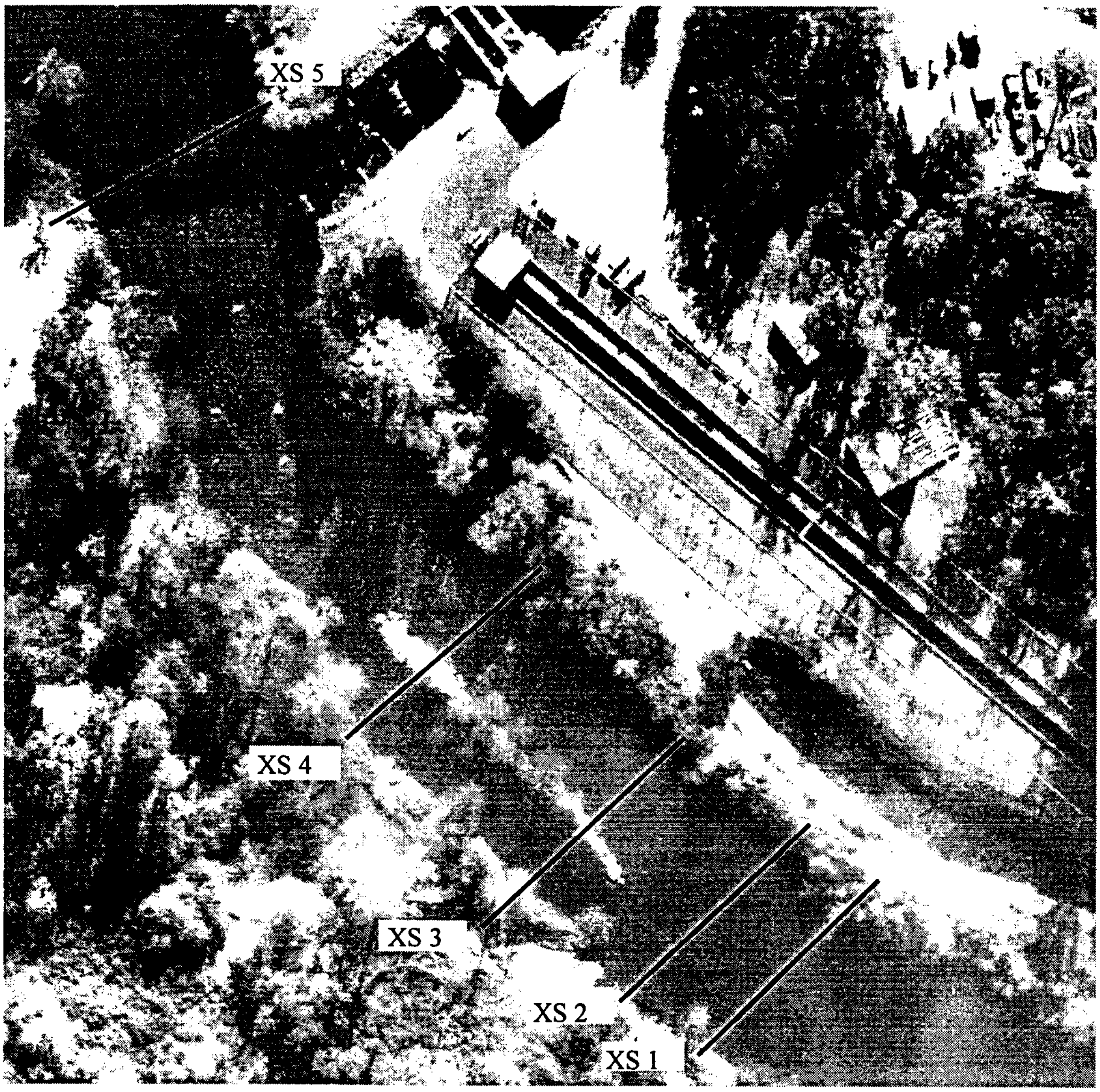


Study Site Locations

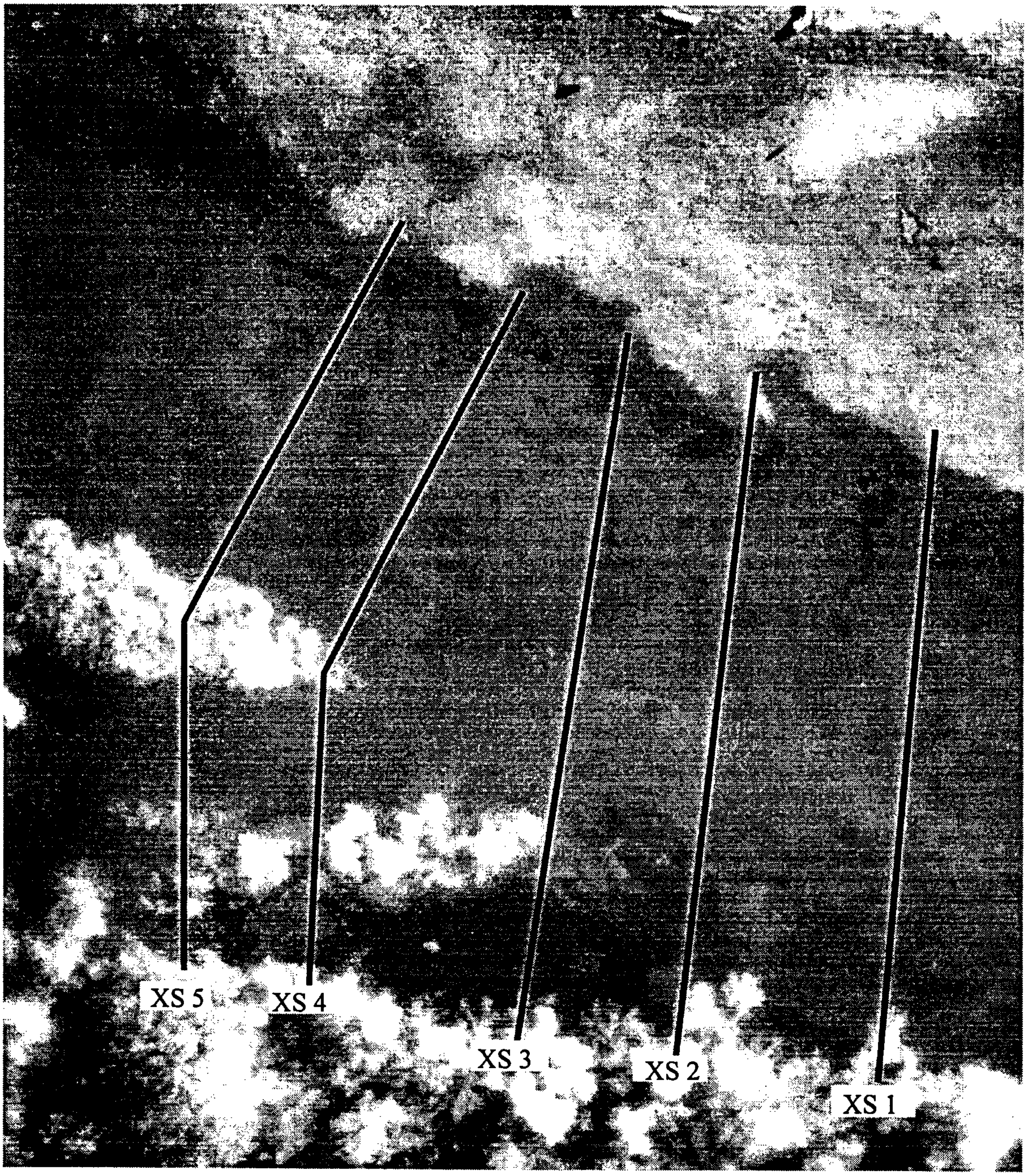


1 = Hatchery
2 = Big Bull Flat
3 = Red's Riffle
4 = Barnowl Riffle
5 = Robinson Riffle
6 = Sodbuster Riffle
7 = Bullfrog Riffles

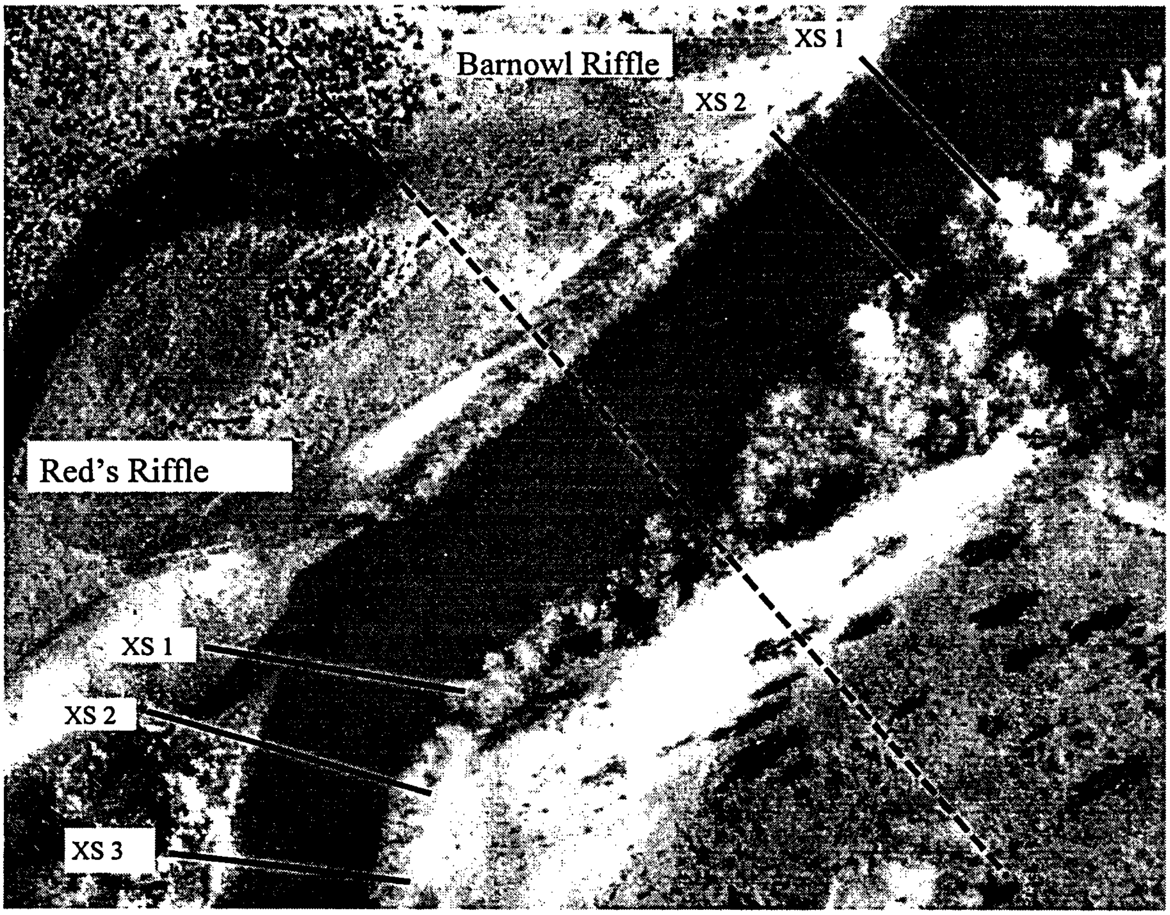
Hatchery Site



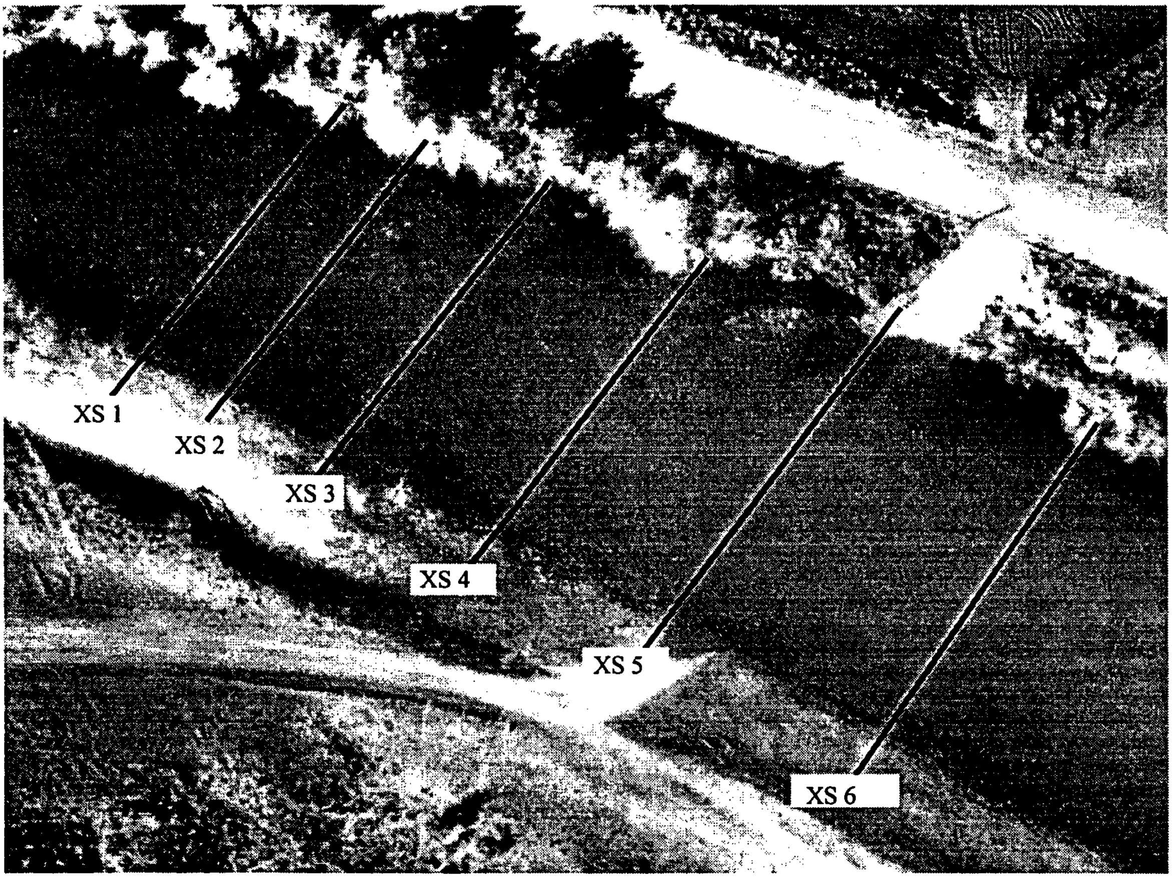
Big Bull Flat



Red's and Barnowl Riffles



Robinson Riffle



Sodbuster Riffle

Bullfrog Riffles

APPENDIX B
WSEL CALIBRATION

Calibration Methods and Parameters Used

Study Site	XS #	Flow Range	Calibration Flows	Method	Parameters
Hatchery	1, 2	200 - 700	249, 463, 1063	IFG4	---
Hatchery	3 RC	117 - 503	180, 322, 687	IFG4	SZF = 98.3
Hatchery	3 LC	83 - 197	69, 144, 336	IFG4	SZF = 98.2
Hatchery	4 RC	117 - 503	180, 322, 674	WSP	n = 0.045, 180 RM = 0.91, 322 RM = 0.86, 674 RM = 0.81
Hatchery	4 LC	83 - 197	69, 144, 329	IFG4	---
Hatchery	5	200 - 700	225, 455, 1003	IFG4	SZF = 100.2
Big Bull Flat	4, 5 LC	15 - 58	8, 27, 55	IFG4	---
Big Bull Flat	4, 5 MC	75 - 224	59, 103, 161, 357	IFG4	---
Big Bull Flat	4, 5 RC	110 - 390	78, 167, 273, 646	IFG4	---
Big Bull Flat	1	200 - 700	153, 297, 472, 1154	MANSQ	β = 0.37, CALQ = 472
Big Bull Flat	2, 3	200 - 700	153, 297, 472, 1154	IFG4	---
Robinson Riffle	1	200 - 700	82, 264, 422, 1046	MANSQ	β = 0.17, CALQ = 246
Robinson Riffle	2 - 6	200 - 700	82, 264, 422, 1046	IFG4	---
Barnowl Riffle	1, 2	200 - 700	82, 264, 430, 1063	IFG4	---
Red's Riffle	1, 2	200 - 700	82, 264, 430, 1063	IFG4	---
Red's Riffle	3	200 - 700	82, 264, 430, 1063	MANSQ	β = 0.30, CALQ = 1063
Sodbuster Riffle	1, 3	200 - 700	88, 264, 422, 1063	IFG4	---
Sodbuster Riffle	2	200 - 700	88, 264, 422, 1063	MANSQ	β = 0.01, CALQ = 1063
Bullfrog Riffles	1 - 4	200 - 700	88, 264, 422, 1063	IFG4	---

HATCHERY STUDY SITE - XS 1 & 2

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 463 cfs	Difference (measured vs. pred. WSELs) 282 cfs	463 cfs	1063 cfs
1	4.31	3.35	5.2	0.03	0.05	0.02
2	3.41	1.46	2.2	0.01	0.02	0.01

HATCHERY STUDY SITE - XS 3 RIGHT CHANNEL

BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 322 cfs	Difference (measured vs. pred. WSELs) 180 cfs	322 cfs	753 cfs
1.49	6.20	9.8	0.05	0.10	0.06

HATCHERY STUDY SITE - XS 3 LEFT CHANNEL

BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 144 cfs	Difference (measured vs. pred. WSELs) 102 cfs	144 cfs	270 cfs
2.21	0.28	0.4	None	None	None

HATCHERY STUDY SITE - XS 4 RIGHT CHANNEL

BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 322 cfs	Difference (measured vs. pred. WSELs) 180 cfs	322 cfs	737 cfs
N/A	N/A	N/A	0.06	0.10	0.05

HATCHERY STUDY SITE - XS 4 LEFT CHANNEL

BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 144 cfs	Difference (measured vs. pred. WSELs) 102 cfs	144 cfs	266 cfs
1.54	4.34	6.8	0.02	0.05	0.04

HATCHERY STUDY SITE - XS 5

BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 455 cfs	Difference (measured vs. pred. WSELs) 258 cfs	455 cfs	1003 cfs
1.42	7.43	11.9	0.04	0.10	0.07

BIG BULL FLAT STUDY SITE - LEFT CHANNEL

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 55 cfs	Difference (measured vs. pred. WSELs) 8 cfs	27 cfs	55 cfs
4	5.74	18.38	10.9	0.05	0.10	0.05
5	2.82	8.68	6.7	0.02	0.05	0.03

BIG BULL FLAT STUDY SITE - MIDDLE CHANNEL

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 173 cfs	Difference (measured vs. pred. WSELs) 59 cfs	103 cfs	173 cfs	357 cfs
4	2.80	1.79	2.1	0.01	0.03	0.02	None
5	2.38	0.86	1.7	None	0.01	0.02	0.01

BIG BULL FLAT STUDY SITE - RIGHT CHANNEL

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 273 cfs	Difference (measured vs. pred. WSELs) 78 cfs	167 cfs	273 cfs	646 cfs
4	2.55	8.44	4.1	0.06	0.08	0.03	0.06
5	2.61	7.03	3.6	0.05	0.07	0.03	0.05

BIG BULL FLAT STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 472 cfs	Difference (measured vs. pred. WSELs) 153 cfs	297 cfs	472 cfs	1154 cfs
1	N/A	9.4	0.0	0.09	0.09	None	0.04
2	2.96	9.40	7.1	0.08	0.08	0.06	0.07
3	2.98	9.38	7.2	0.08	0.09	0.06	0.07

ROBINSON RIFFLE STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 422 cfs	Difference (measured vs. pred. WSELs) 82 cfs	264 cfs	422 cfs	1046 cfs
1	N/A	9.1	7.6	0.07	None	0.05	0.06
2	3.06	5.87	12.7	0.02	None	0.07	0.05
3	3.20	4.83	10.3	0.01	0.01	0.06	0.04
4	3.43	3.64	7.0	0.01	None	0.04	0.03
5	3.41	5.29	7.2	0.02	0.02	0.04	0.04
6	3.43	3.87	0.2	0.02	0.04	None	0.03

BARNOWL RIFFLE STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 430 cfs	Difference (measured vs. pred. WSELs) 82 cfs	264 cfs	430 cfs	1063 cfs
1	2.17	3.10	0.9	~~0.02~~ 0.01	~~0.05~~ 0.04	0.01	0.05
2	2.37	2.09	2.0	~~0.01~~ None	~~0.02~~ 0.01	0.02	0.04

RED'S RIFFLE STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 430 cfs	Difference (measured vs. pred. WSELs) 82 cfs	264 cfs	430 cfs	1063 cfs
1	2.12	6.87	3.9	0.04	0.08	0.04	0.10
2	2.50	6.18	7.4	0.03	0.04	0.07	0.09
3	N/A	2.18	2.3	0.02	0.01	0.01	None

SODBUSTER RIFFLE STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 422 cfs	Difference (measured vs. pred. WSELs) 88 cfs	264 cfs	430 cfs	1063 cfs
1	2.20	0.91	1.8	None	None	0.02	0.02
2	N/A	7.26	7.8	0.06	0.06	0.04	None
3	2.69	6.49	4.2	0.03	0.07	0.04	0.10

BULLFROG RIFFLES STUDY SITE

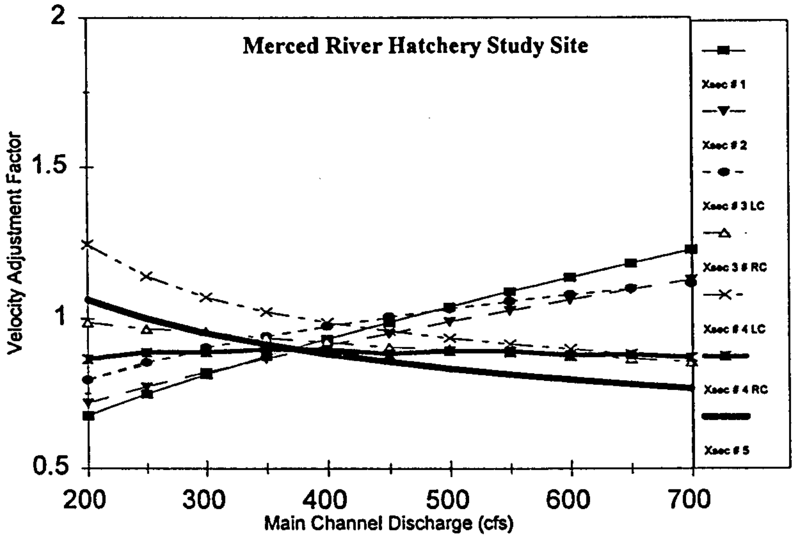
XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 422 cfs	Difference (measured vs. pred. WSELs) 88 cfs	264 cfs	430 cfs	1063 cfs
1	2.33	3.12	6.5	0.01	0.01	0.06	0.05
2	3.11	9.88	10.9	0.05	0.06	0.08	0.10
3	2.97	6.85	10.8	0.03	0.03	0.09	0.09
4	3.40	8.31	9.0	0.04	0.05	0.06	0.08

APPENDIX C
VELOCITY CALIBRATION

HATCHERY STUDY SITE

Velocity Adjustment Factors

Main Channel Discharge	Xsec 1	Xsec 2	Xsec 3 Left Channel	Xsec 3 Right Channel	Xsec 4 Left Channel	Xsec 4 Right Channel	Xsec 5
200	0.675	0.718	0.798	0.988	1.243	0.866	1.062
250	0.748	0.772	0.855	0.966	1.139	0.887	1
300	0.814	0.822	0.904	0.958	1.07	0.888	0.952
350	0.876	0.868	0.943	0.936	1.023	0.897	0.914
400	0.933	0.911	0.977	0.921	0.988	0.898	0.883
450	0.988	0.951	1.007	0.904	0.96	0.884	0.857
500	1.039	0.99	1.035	0.9	0.936	0.893	0.834
550	1.089	1.027	1.058	0.887	0.916	0.892	0.815
600	1.136	1.062	1.08	0.874	0.9	0.879	0.798
650	1.182	1.096	1.1	0.867	0.885	0.881	0.782
700	1.226	1.129	1.119	0.856	0.871	0.871	0.768



HATCHERY STUDY SITE

Velocity Calibration Details (feet per second)

Transect 1

	Measured	Simulated		
Discharge	463	200	463	700
average vel	1.21	0.72	1.25	1.56
std dev	0.75	0.39	0.71	1.00
max vel	2.42	1.32	2.45	3.33
min vel	0.00	0.01	0.04	0.07
avg diff m-v-s			**0.05**	
max diff m-v-s			**0.43**	
+/-			**1.13**	

Transect 2

	Measured	Simulated		
Discharge	463	200	463	700
average vel	1.42	0.88	1.35	1.47
std dev	1.08	0.60	1.08	1.48
max vel	3.73	2.09	3.61	4.75
min vel	-0.61	-0.25	-0.59	-0.85
avg diff m-v-s			**0.09**	
max diff m-v-s			**0.42**	
+/-			**-1.90**	

Transect 3 Left Channel

	Measured	Simulated		
Discharge	144	83	144	197
average vel	1.85	1.10	1.87	2.27
std dev	0.70	0.43	0.71	1.06
max vel	2.55	1.57	2.59	3.21
min vel		0.04	0.11	0.13
avg diff m-v-s			**0.03**	
max diff m-v-s			**0.04**	
+/-			**0.56**	

Transect 3 Right Channel

	Measured	Simulated		
Discharge	322	117	322	503
average vel	3.13	2.34	2.96	3.03
std dev	0.99	0.61	1.08	1.35
max vel	4.33	3.10	4.13	4.82
min vel	0.33	0.39	0.34	0.28
avg diff m-v-s			**0.17**	
max diff m-v-s			**0.24**	
+/-			**-4.00**	

Transect 4 Left Channel

	Measured	Simulated		
Discharge	144	83	144	197
average vel	3.09	2.33	3.03	3.05
std dev	1.10	0.95	1.07	1.52
max vel	4.74	3.69	4.65	5.25
min vel	0.42	0.09	0.42	0.31
avg diff m-v-s			**0.06**	
max diff m-v-s			**0.09**	
+/-			**-1.16**	

Transect 4 Right Channel

	Measured	Simulated		
Discharge	322	117	322	503
average vel	3.61	2.40	3.37	3.35
std dev	1.28	0.88	1.19	1.77
max vel	5.13	3.32	4.81	5.62
min vel	0.16	1.12	0.16	0.14
avg diff m-v-s			**0.24**	
max diff m-v-s			**0.34**	
+/-			**-4.97**	

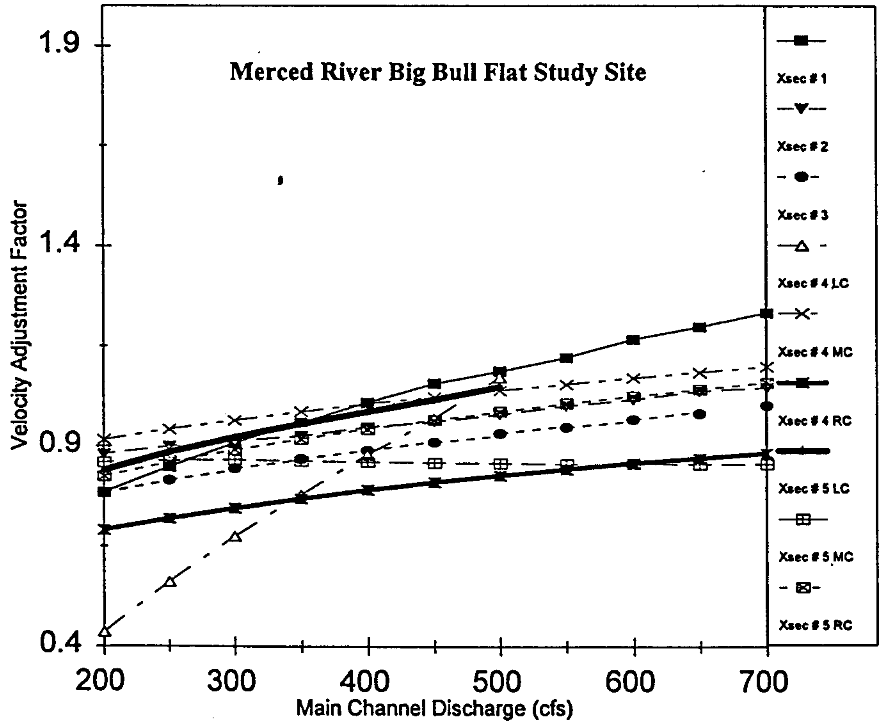
Transect 5

	Measured	Simulated		
Discharge	455	200	455	700
average vel	3.62	2.65	3.29	3.29
std dev	1.66	1.24	1.49	1.92
max vel	5.87	4.46	5.29	5.84
min vel	0.11	0.07	0.10	0.03
avg diff m-v-s			**0.34**	
max diff m-v-s			**0.58**	
+/-			**-9.65**	

BIG BULL FLAT STUDY SITE

Velocity Adjustment Factors

Main Channel Discharge	Xsec 1	Xsec 2	Xsec 3	Xsec 4 Left Channel	Xsec 4 Middle Channel	Xsec 4 Right Channel	Xsec 5 Left Channel	Xsec 5 Middle Channel	Xsec 5 Right Chann
200	0.784	0.88	0.783	0.435	0.917	0.69	0.839	0.859	0.825
250	0.848	0.901	0.815	0.561	0.943	0.719	0.885	0.864	0.859
300	0.908	0.914	0.845	0.675	0.966	0.745	0.923	0.866	0.891
350	0.961	0.926	0.869	0.78	0.988	0.769	0.957	0.863	0.919
400	1.01	0.949	0.89	0.878	1.008	0.791	0.988	0.86	0.944
450	1.058	0.963	0.911	0.972	1.024	0.81	1.018	0.858	0.967
500	1.089	0.981	0.933	1.073	1.041	0.827	1.049	0.857	0.988
550	1.122	1.002	0.949	---	1.056	0.842	---	0.855	1.008
600	1.167	1.018	0.968	---	1.072	0.857	---	0.855	1.026
650	1.198	1.039	0.983	---	1.086	0.87	---	0.854	1.044
700	1.233	1.047	1.003	---	1.1	0.882	---	0.855	1.06



MERCED RIVER VELOCITY CALIBRATION

BIG BULL FLAT STUDY SITE

Velocity Calibration Details (feet per second)

Transect 1

	Measured	Simulated		
Discharge	472	200	472	700
average vel	1.25	0.85	1.34	1.63
std dev	0.79	0.45	0.84	1.11
max vel	3.01	1.88	3.20	4.10
min vel	0.00	0.14	0.0[illegible]	0.05
avg diff m-v-s			0.08	
max diff m-v-s			0.19	
+/-			2.65	

Transect 2

	Measured	Simulated		
Discharge	472	200	472	700
average vel	1.39	0.92	1.40	1.62
std dev	0.96	0.64	0.94	1.17
max vel	3.52	2.33	3.51	4.33
min vel	0.00	0.06	0.21	0.12
avg diff m-v-s			0.02	
max diff m-v-s			0.27	
+/-			0.10	

Transect 3

	Measured	Simulated		
Discharge	472	200	472	700
average vel	1.14	0.74	1.12	1.32
std dev	1.04	0.57	0.94	1.16
max vel	3.80	2.06	3.63	4.80
min vel	0.00	0.04	0.09	0.12
avg diff m-v-s			0.11	
max diff m-v-s			0.45	
+/-			-0.76	

Transect 4 Left Channel

	Measured	Simulated		
Discharge	55	15	55	58
average vel	0.72	0.31	0.76	0.74
std dev	1.05	0.39	1.05	1.07
max vel	2.92	1.07	2.98	3.11
min vel	0.00	0.01	0.04	0.01
avg diff m-v-s			0.05	
max diff m-v-s			0.13	
+/-			0.54	

Transect 4 Middle Channel

	Measured	Simulated		
Discharge	161	75	161	224
average vel	1.25	1.14	1.37	1.66
std dev	1.09	0.79	1.11	1.25
max vel	3.03	2.31	3.20	3.69
min vel	0.00	0.12	0.06	0.08
avg diff m-v-s			0.12	
max diff m-v-s			0.35	
+/-			2.49	

Transect 4 Right Channel

	Measured	Simulated		
Discharge	273	110	273	390
average vel	1.07	0.81	1.07	1.07
std dev	0.85	0.33	0.61	0.73
max vel	2.98	1.59	2.53	3.02
min vel	0.00	0.09	0.12	0.15
avg diff m-v-s			0.35	
max diff m-v-s			1.67	
+/-			-1.04	

Transect 5 Left Channel

	Measured	Simulated		
Discharge	55	15	55	58
average vel	1.86	0.92	1.90	1.78
std dev	1.29	0.78	1.29	1.38
max vel	3.41	2.07	3.48	3.56
min vel	0.00	0.02	0.09	0.00
avg diff m-v-s			0.04	
max diff m-v-s			0.10	
+/-			0.45	

Transect 5 Middle Channel

	Measured	Simulated		
Discharge	161	75	161	224
average vel	1.94	1.09	1.72	1.85
std dev	0.81	0.78	0.70	0.86
max vel	3.16	2.21	2.76	3.03
min vel	0.63	0.00	0.59	0.16
avg diff m-v-s			0.21	
max diff m-v-s			0.40	
+/-			-4.10	

Transect 5 Right Channel

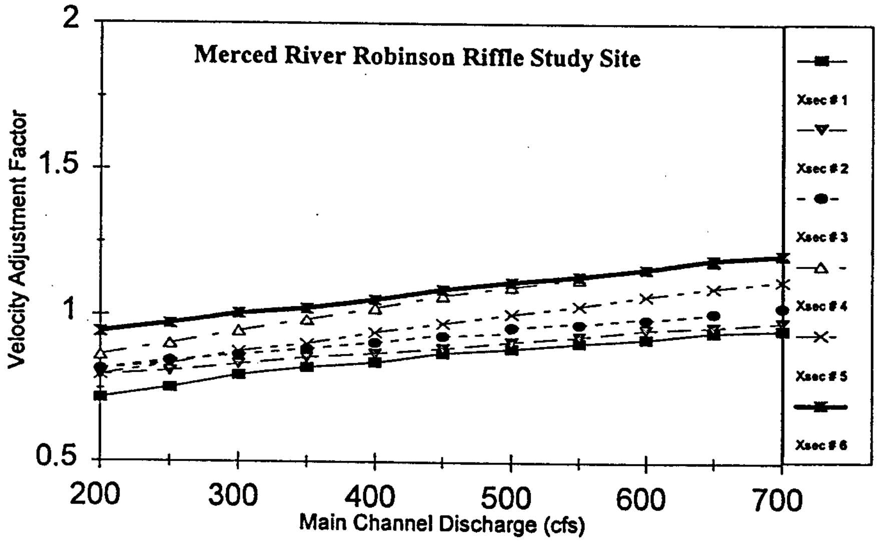
	Measured	Simulated		
Discharge	273	110	273	390
average vel	0.95	0.83	0.98	1.10
std dev	0.87	0.46	0.84	1.00
max vel	2.96	1.89	3.00	3.59
min vel	0.00	0.12	0.02	0.02
avg diff m-v-s			0.06	
max diff m-v-s			0.40	
+/-			1.71	

MERCED RIVER VELOCITY CALIBRATION

ROBINSON RIFFLE STUDY SITE

Velocity Adjustment Factors

Simulated Discharge	Xsec 1	Xsec 2	Xsec 3	Xsec 4	Xsec 5	Xsec 6
200	0.719	0.796	0.817	0.864	0.797	0.942
250	0.755	0.81	0.846	0.903	0.834	0.971
300	0.797	0.834	0.866	0.946	0.876	1.005
350	0.824	0.857	0.886	0.984	0.903	1.023
400	0.841	0.87	0.907	1.024	0.942	1.054
450	0.873	0.888	0.931	1.066	0.972	1.089
500	0.887	0.911	0.959	1.099	1.006	1.115
550	0.907	0.929	0.97	1.125	1.033	1.134
600	0.922	0.953	0.987	1.159	1.067	1.16
650	0.944	0.962	1.011	1.187	1.096	1.193
700	0.952	0.979	1.031	1.211	1.12	1.209



MERCED RIVER VELOCITY CALIBRATION

ROBINSON RIFFLE STUDY SITE

Velocity Calibration Details (feet per second)

Transect 1

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.64	1.49	2.32	2.82
std dev	1.00	0.68	0.86	1.27
max vel	4.39	2.73	3.82	4.81
min vel	0.37	0.11	0.34	0.07
avg diff m-v-s			**0.32**	
max diff m-v-s			**0.57**	
+/-			**-12.14**	

Transect 2

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.56	1.58	2.30	2.92
std dev	1.11	0.78	1.05	1.41
max vel	4.35	2.98	3.94	4.93
min vel	0.00	0.04	0.08	0.16
avg diff m-v-s			**0.21**	
max diff m-v-s			**0.41**	
+/-			**-7.56**	

Transect 3

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.15	1.41	2.06	2.59
std dev	0.91	0.65	0.84	1.13
max vel	3.63	2.54	3.42	4.30
min vel	0.00	0.09	0.11	0.17
avg diff m-v-s			**0.10**	
max diff m-v-s			**0.21**	
+/-			**-3.99**	

Transect 4

	Measured	Simulated		
Discharge	422	200	422	700
average vel	1.82	1.25	1.97	2.54
std dev	0.97	0.69	0.98	1.39
max vel	3.13	2.27	3.31	4.66
min vel	0.00	0.00	0.20	0.15
avg diff m-v-s			**0.15**	
max diff m-v-s			**0.69**	
+/-			**6.16**	

Transect 5

	Measured	Simulated		
Discharge	422	200	422	700
average vel	1.90	1.29	1.88	2.48
std dev	0.65	0.36	0.59	0.80
max vel	2.77	1.76	2.71	3.67
min vel	0.00	0.08	0.17	0.35
avg diff m-v-s			**0.06**	
max diff m-v-s			**0.52**	
+/-			**-1.03**	

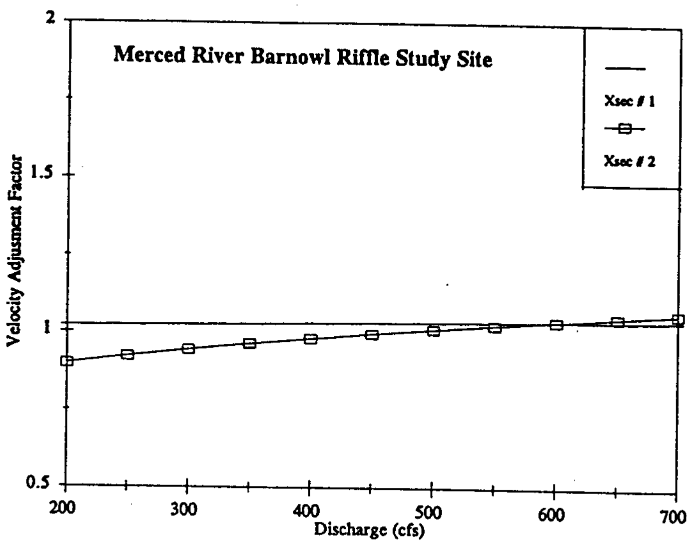
Transect 6

	Measured	Simulated		
Discharge	422	200	422	700
average vel	1.57	1.14	1.69	2.19
std dev	0.60	0.41	0.62	0.89
max vel	2.38	1.86	2.55	3.29
min vel	0.00	0.08	0.10	0.13
avg diff m-v-s			**0.12**	
max diff m-v-s			**0.30**	
+/-			**5.68**	

MERCED RIVER VELOCITY CALIBRATION

BARNOWL RIFFLE STUDY SITE

Simulated Discharge	Xsec 1	Xsec 2
200	1.022	0.899
250	1.023	0.923
300	1.025	0.945
350	1.027	0.964
400	1.03	0.981
450	1.032	0.997
500	1.034	1.012
550	1.037	1.026
600	1.039	1.039
650	1.04	1.052
700	1.042	1.064



Velocity Calibration Details (feet per second)

Transect 1

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.86	2.23	2.97	3.16
std dev	0.94	0.74	0.97	1.49
max vel	4.11	3.24	4.25	5.05
min vel	0.10	0.39	0.11	0.06
avg diff m-v-s			**0.10**	
max diff m-v-s			**0.14**	
+/-			**3.46**	

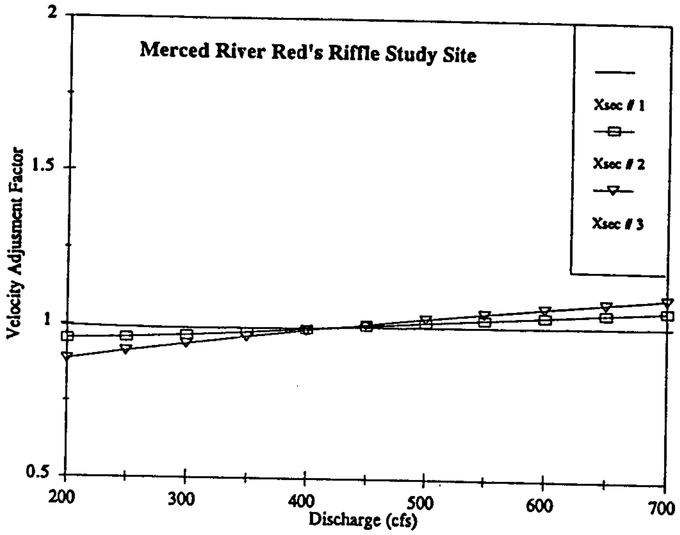
Transect 2

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.41	1.51	2.07	2.41
std dev	0.82	0.78	1.08	1.44
max vel	3.66	2.64	3.65	4.51
min vel	0.13	0.05	0.04	0.05
avg diff m-v-s			**0.04**	
max diff m-v-s			**0.35**	
+/-			**1.82**	

MERCED RIVER

RED'S RIFFLE STUDY SITE

Simulated Discharge	Xsec 1	Xsec 2	Xsec 3
200	0.995	0.954	0.885
250	0.991	0.959	0.913
300	0.990	0.968	0.939
350	0.991	0.978	0.963
400	0.993	0.990	0.985
450	0.996	1.002	1.007
500	0.997	1.014	1.027
550	0.999	1.025	1.046
600	1.002	1.037	1.065
650	1.004	1.048	1.083
700	1.005	1.059	1.100



Velocity Calibration Details (feet per second)

Transect 1

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.98	2.26	2.94	3.23
std dev	0.95	0.71	1.00	1.48
max vel	4.37	3.46	4.40	5.22
min vel	0.27	0.56	2.28	0.22
avg diff m-v-s			**0.06**	
max diff m-v-s			**0.94**	
+/-			**2.92**	

Transect 2

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.69	1.98	2.60	3.13
std dev	1.23	0.88	1.36	1.79
max vel	4.18	3.24	4.26	5.21
min vel	0.00	0.02	0.02	0.05
avg diff m-v-s			**0.07**	
max diff m-v-s			**0.17**	
+/-			**2.38**	

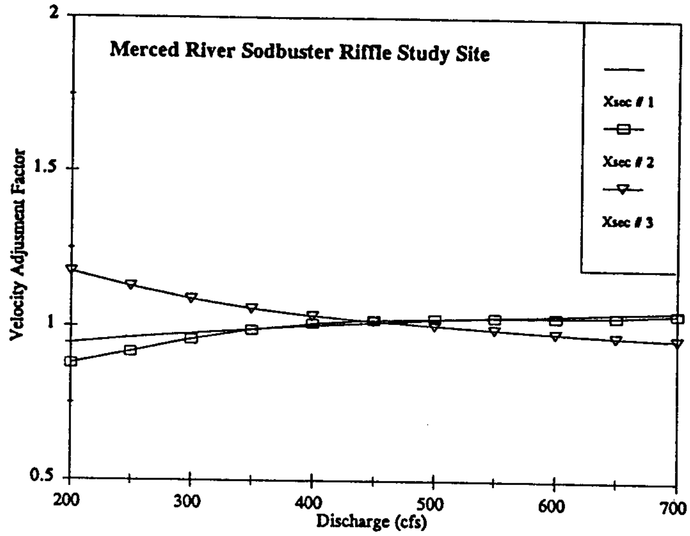
Transect 3

	Measured	Simulated		
Discharge	422	200	422	700
average vel	3.24	2.19	2.87	3.58
std dev	1.50	1.03	1.72	2.28
max vel	5.67	4.09	5.60	6.97
min vel	0.16	0.09	0.01	0.01
avg diff m-v-s			**0.03**	
max diff m-v-s			**0.09**	
+/-			**0.89**	

MERCED RIVER

SODBUSTER RIFFLE STUDY SITE

Simulated Discharge	Xsec 1	Xsec 2	Xsec 3
200	0.946	0.88	1.175
250	0.963	0.919	1.128
300	0.978	0.959	1.089
350	0.992	0.99	1.059
400	1.004	1.012	1.037
450	1.014	1.023	1.019
500	1.024	1.028	1.005
550	1.033	1.032	0.992
600	1.041	1.034	0.981
650	1.049	1.038	0.971
700	1.056	1.047	0.963



Velocity Calibration Details (feet per second)

Transect 1

	Measured	Simulated		
Discharge	422	200	422	700
average vel	1.95	1.60	1.82	2.13
std dev	1.45	0.96	1.40	1.69
max vel	3.96	2.96	4.02	4.83
min vel	0.00	0.08	0.01	0.08
avg diff m-v-s			**0.17**	
max diff m-v-s			**1.11**	
+/-			**6.57**	

Transect 2

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.11	1.84	2.15	2.51
std dev	1.21	1.09	1.29	1.52
max vel	3.78	3.20	4.10	4.80
min vel	0.00	0.06	0.07	0.06
avg diff m-v-s			**0.21**	
max diff m-v-s			**0.69**	
+/-			**7.20**	

Transect 3

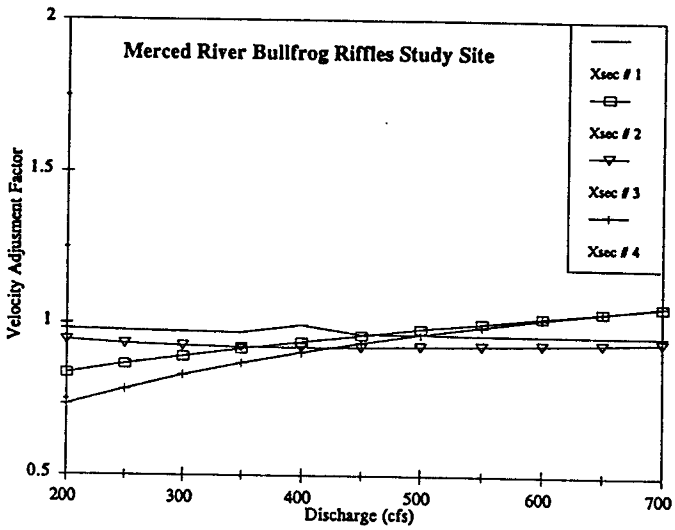
	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.02	1.69	2.04	2.24
std dev	1.19	1.10	1.18	1.30
max vel	3.53	3.34	3.59	3.85
min vel	0.00	0.03	0.20	0.17
avg diff m-v-s			**0.19**	
max diff m-v-s			**2.02**	
+/-			**10.78**	

MERCED RIVER

BULLFROG RIFFLES STUDY SITE

Velocity Adjustment Factors

Simulated Discharge	Xsec 1	Xsec 2	Xsec 3	Xsec 4
200	0.982	0.837	0.945	0.732
250	0.978	0.866	0.934	0.785
300	0.975	0.892	0.927	0.831
350	0.972	0.917	0.923	0.871
400	0.997	0.941	0.922	0.906
450	0.968	0.963	0.923	0.938
500	0.966	0.985	0.926	0.967
550	0.964	1.005	0.929	0.994
600	0.964	1.025	0.934	1.02
650	0.964	1.044	0.939	1.043
700	0.964	1.062	0.945	1.065



Velocity Calibration Details (feet per second)

Transect 1

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.81	2.30	2.60	3.05
std dev	1.13	0.70	1.21	1.39
max vel	4.03	3.06	3.98	4.73
min vel	0.35	0.67	0.15	0.35
avg diff m-v-s			**0.11**	
max diff m-v-s			**1.54**	
+/-			**4.04**	

Transect 2

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.31	1.57	2.16	2.81
std dev	0.98	0.70	1.03	1.29
max vel	3.83	2.64	3.75	4.82
min vel	0.31	0.09	0.03	0.11
avg diff m-v-s			**0.24**	
max diff m-v-s			**0.96**	
+/-			**4.65**	

Transect 3

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.65	1.69	2.32	2.85
std dev	1.23	1.07	1.29	1.54
max vel	4.54	3.20	4.39	5.64
min vel	0.25	0.06	0.03	0.09
avg diff m-v-s			**0.25**	
max diff m-v-s			**0.88**	
+/-			**9.70**	

Transect 4

	Measured	Simulated		
Discharge	422	200	422	700
average vel	2.60	1.46	2.05	2.79
std dev	0.96	0.75	1.10	1.31
max vel	3.82	2.40	3.58	4.64
min vel	0.41	0.01	0.16	0.30
avg diff m-v-s			**0.27**	
max diff m-v-s			**1.19**	
+/-			**10.82**	

APPENDIX D
HSI CRITERIA

Merced River Smoothed Tail with Correction for Depth Availability

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0.00	0.00	0.00	0.00	0.00	0.00
0.40	0.00	0.30	0.00	1.00	0.08
0.42	0.07	0.67	0.39	2.00	0.71
0.51	0.11	0.72	0.49	3.00	1.00
0.60	0.15	0.82	0.70	4.00	0.00
0.69	0.21	0.87	0.79	5.00	0.00
0.83	0.33	0.91	0.88	100.00	0.00
0.92	0.41	1.01	0.98		
1.01	0.51	1.06	1.00		
1.10	0.61	1.09	1.00		
1.19	0.70	24.00	0.00		
1.29	0.79	100.00	0.00		
1.38	0.87				
1.47	0.93				
1.65	1.00				
1.74	1.00				
1.83	0.98				
1.92	0.95				
2.01	0.90				
2.11	0.84				
2.20	0.77				
2.29	0.70				
2.47	0.55				
2.56	0.48				
2.65	0.41				
2.74	0.35				
2.88	0.27				
2.95	0.21				
3.02	0.20				
3.15	0.15				
3.29	0.11				
3.38	0.08				
3.47	0.07				
3.56	0.05				
3.65	0.04				
3.75	0.03				
3.84	0.02				
3.93	0.02				
4.06	0.01				
100.00	0.00				

Merced River Smoothed Head with Correction for Depth Availability

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0.00	0.00	0.00	0.00	0.00	0.00
0.40	0.00	0.30	0.00	1.00	0.01
0.42	0.07	0.67	0.39	2.00	0.26
0.51	0.11	0.72	0.49	3.00	1.00
0.60	0.15	0.82	0.70	4.00	0.21
0.69	0.21	0.87	0.79	5.00	0.00
0.83	0.33	0.91	0.88	100.00	0.00
0.92	0.41	1.01	0.98		
1.01	0.51	1.06	1.00		
1.10	0.61	1.09	1.00		
1.19	0.70	24.00	0.00		
1.29	0.79	100.00	0.00		
1.38	0.87				
1.47	0.93				
1.65	1.00				
1.74	1.00				
1.83	0.98				
1.92	0.95				
2.01	0.90				
2.11	0.84				
2.20	0.77				
2.29	0.70				
2.47	0.55				
2.56	0.48				
2.65	0.41				
2.74	0.35				
2.88	0.27				
2.95	0.21				
3.02	0.20				
3.15	0.15				
3.29	0.11				
3.38	0.08				
3.47	0.07				
3.56	0.05				
3.65	0.04				
3.75	0.03				
3.84	0.02				
3.93	0.02				
4.06	0.01				
100.00	0.00				

Merced River Nonparametric Tail with Correction for Depth Availability

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0.00	0.00	0.00	0.00	0.00	0.00
0.40	0.00	0.30	0.00	1.00	0.08
0.82	0.10	0.60	0.10	2.00	0.71
0.88	0.20	0.61	0.20	3.00	1.00
1.05	0.50	0.80	0.50	4.00	0.00
1.36	1.00	0.90	1.00	5.00	0.00
2.26	1.00	1.40	1.00	100.00	0.00
2.57	0.50	24.00	0.00		
2.95	0.20	100.00	0.00		
3.27	0.10				
4.20	0.00				
100.00	0.00				

Merced River Nonparametric Head with Correction for Depth Availability

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0.00	0.00	0.00	0.00	0.00	0.00
0.40	0.00	0.30	0.00	1.00	0.01
0.82	0.10	0.60	0.10	2.00	0.26
0.88	0.20	0.61	0.20	3.00	1.00
1.05	0.50	0.80	0.50	4.00	0.21
1.36	1.00	0.90	1.00	5.00	0.00
2.26	1.00	1.40	1.00	100.00	0.00
2.57	0.50	24.00	0.00		
2.95	0.20	100.00	0.00		
3.27	0.10				
4.20	0.00				
100.00	0.00				

Stanislaus River Smoothed Use

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0.00	0.00	0.00	0.00	0.00	0.00
0.30	0.00	0.50	0.00	1.00	0.42
0.53	0.18	0.53	0.03	2.00	0.80
0.64	0.25	0.74	0.11	3.00	1.00
0.85	0.42	0.85	0.18	4.00	0.42
0.95	0.51	0.95	0.27	5.00	0.00
1.05	0.61	1.05	0.38	100.00	0.00
1.16	0.71	1.16	0.50		
1.26	0.80	1.26	0.63		
1.47	0.94	1.37	0.75		
1.68	1.00	1.47	0.85		
1.79	1.00	1.68	0.98		
1.89	0.97	1.84	1.00		
2.10	0.87	1.99	0.96		
2.31	0.72	2.10	0.91		
2.41	0.64	2.20	0.84		
2.52	0.56	2.31	0.77		
2.62	0.48	2.41	0.69		
2.73	0.41	2.52	0.61		
2.83	0.35	2.62	0.54		
2.93	0.29	2.73	0.47		
3.14	0.19	2.93	0.36		
3.35	0.13	3.09	0.29		
3.46	0.10	3.14	0.27		
3.77	0.05	3.35	0.20		
3.93	0.04	3.46	0.17		
4.08	0.02	3.56	0.15		
4.43	0.01	3.87	0.09		
100.00	0.00	4.08	0.07		
		4.29	0.05		
		100.00	0.00		

Stanislaus River Nonparametric Use

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0.00	0.00	0.00	0.00	0.00	0.00
0.30	0.00	0.50	0.00	1.00	0.42
0.70	0.10	0.70	0.10	2.00	0.80
0.80	0.20	1.00	0.20	3.00	1.00
1.10	0.50	1.30	0.50	4.00	0.42
1.30	1.00	1.60	1.00	5.00	0.00
2.40	1.00	2.50	1.00	100.00	0.00
2.60	0.50	3.00	0.50		
3.10	0.20	3.50	0.20		
3.50	0.10	3.80	0.10		
4.80	0.00	4.80	0.00		
100.00	0.00	100.00	0.00		

Tuolumne River

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.00	0.50	0.00	1.00	0.26
0.70	0.00	0.60	0.12	2.00	1.00
0.80	0.06	0.70	0.23	3.00	1.00
0.90	0.17	0.80	0.27	4.00	0.30
1.05	0.36	0.90	1.00	5.00	0.00
1.25	0.42	2.60	1.00	100.00	0.00
1.40	1.00	2.70	0.15		
2.60	1.00	2.80	0.12		
2.70	0.62	2.90	0.08		
2.80	0.56	3.00	0.00		
2.90	0.45	100.00	0.00		
3.05	0.22				
3.20	0.17				
3.80	0.07				
4.40	0.00				
100.00	0.00				

Merced River Smoothed Tail with Original Depths

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0.00	0.00	0.00	0.00	0.00	0.00
0.40	0.00	0.30	0.00	1.00	0.08
0.42	0.07	0.67	0.39	2.00	0.71
0.51	0.11	0.72	0.49	3.00	1.00
0.60	0.15	0.82	0.70	4.00	0.00
0.69	0.21	0.87	0.79	5.00	0.00
0.83	0.33	0.91	0.88	100.00	0.00
0.92	0.41	1.01	0.98		
1.01	0.51	1.06	1.00		
1.10	0.61	1.09	1.00		
1.19	0.70	1.13	0.98		
1.29	0.79	1.18	0.94		
1.38	0.87	1.28	0.82		
1.47	0.93	1.33	0.75		
1.65	1.00	1.38	0.67		
1.74	1.00	1.43	0.60		
1.83	0.98	1.48	0.52		
1.92	0.95	1.53	0.45		
2.01	0.90	1.57	0.39		
2.11	0.84	1.62	0.34		
2.20	0.77	1.70	0.26		
2.29	0.70	1.75	0.22		
2.47	0.55	1.79	0.19		
2.56	0.48	1.84	0.16		
2.65	0.41	1.89	0.14		
2.74	0.35	1.92	0.13		
2.88	0.27	1.99	0.10		
2.95	0.21	2.09	0.08		
3.02	0.20	2.19	0.06		
3.15	0.15	100.00	0.00		
3.29	0.11				
3.38	0.08				
3.47	0.07				
3.56	0.05				
3.65	0.04				
3.75	0.03				
3.84	0.02				
3.93	0.02				
4.06	0.01				
100.00	0.00				

APPENDIX E
HABITAT MODELING RESULTS

Hatchery Study Site - Transect 1

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	23.38	24.90	18.85	20.11	23.15	19.80	10.06	3.71
250	30.88	32.86	30.48	32.39	27.52	29.42	18.31	3.11
300	36.79	39.15	38.55	40.83	28.84	33.98	24.43	2.70
350	40.62	43.24	42.98	45.41	27.76	35.15	28.53	2.68
400	42.31	45.05	45.36	47.94	25.22	36.18	29.37	2.74
450	42.30	45.06	46.36	49.10	21.95	34.88	31.54	2.75
500	40.92	43.61	44.60	47.55	18.63	31.45	21.89	2.68
550	38.84	41.43	42.44	45.59	15.52	26.86	13.57	2.55
600	36.51	38.98	39.58	42.44	12.93	22.14	6.14	2.50
650	33.51	35.85	36.87	39.38	10.74	17.34	2.33	2.31
700	30.58	32.80	33.38	35.70	8.99	13.53	1.16	2.11

Hatchery Study Site - Transect 2

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	29.97	30.89	28.79	29.85	31.42	29.99	27.91	10.72
250	33.47	34.24	34.02	34.97	34.54	37.56	34.99	10.01
300	34.96	35.66	36.09	36.92	34.97	40.78	40.79	8.65
350	34.79	35.46	37.22	38.15	33.75	43.85	38.44	6.88
400	33.72	34.43	37.02	37.94	31.41	42.08	35.81	5.26
450	32.12	32.85	34.99	35.87	28.61	40.24	28.77	3.98
500	30.29	31.04	32.51	33.36	25.67	35.71	23.23	3.08
550	28.34	29.09	31.02	31.87	22.68	31.87	19.27	2.48
600	26.35	27.14	28.16	29.28	19.92	28.58	17.66	2.03
650	24.24	25.01	25.47	26.69	17.29	24.19	17.09	1.71
700	22.56	23.25	23.94	24.87	15.01	21.38	12.01	1.50

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Hatchery Study Site - Transect 3, Left Channel

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	15.30	15.95	16.86	17.46	13.03	11.64	15.45	11.02
250	17.80	18.60	18.63	19.34	18.02	17.59	20.69	9.37
300	18.32	19.24	19.08	20.00	20.89	21.16	21.89	6.66
350	17.46	18.52	19.11	20.22	21.23	22.58	22.68	4.45
400	15.89	17.06	19.00	20.35	19.97	23.35	23.00	2.86
450	14.01	15.23	17.72	19.05	17.89	23.53	23.23	1.84
500	11.91	13.13	14.79	15.97	15.27	21.46	23.24	1.18
550	10.06	11.25	11.70	12.93	12.85	17.83	21.69	0.82
600	8.40	9.55	9.32	10.63	10.66	14.75	19.02	0.61
650	6.89	8.00	7.52	8.83	8.74	12.53	16.22	0.46
700	5.63	6.67	6.10	7.32	7.05	10.85	12.16	0.36

Hatchery Study Site - Transect 3, Right Channel

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	24.67	25.41	30.33	31.12	10.20	9.04	38.96	24.51
250	20.90	21.66	24.20	24.98	12.11	10.51	34.97	19.80
300	16.16	16.98	18.18	19.00	12.47	11.18	29.01	13.70
350	13.05	13.98	14.24	15.31	12.92	12.57	25.16	8.81
400	10.25	11.22	10.95	11.98	12.27	12.79	21.05	5.20
450	8.31	9.26	8.65	9.65	11.49	12.30	16.72	2.95
500	6.75	7.65	6.85	7.81	9.99	10.71	12.70	1.74
550	5.49	6.37	5.53	6.47	8.76	9.71	10.53	0.99
600	4.68	5.53	4.55	5.48	7.75	8.98	9.06	0.60
650	3.90	4.70	3.79	4.70	6.56	8.11	7.70	0.38
700	3.23	4.00	3.27	4.16	5.56	7.39	6.93	0.24

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Hatchery Study Site - Transect 4, Left Channel

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	3.20	3.22	1.23	1.24	0.30	0.25	0.81	3.20
250	4.40	4.43	2.86	2.88	0.94	0.96	2.87	4.40
300	5.70	5.76	4.49	4.51	1.44	1.39	4.53	5.70
350	6.79	6.86	6.53	6.58	1.98	1.64	7.25	6.79
400	7.07	7.17	7.69	7.74	2.55	2.00	9.08	7.07
450	6.96	7.08	7.52	7.59	3.07	2.49	9.31	6.91
500	6.65	6.79	7.57	7.64	3.55	2.94	9.74	6.40
550	6.36	6.52	7.48	7.56	3.96	3.28	9.96	5.81
600	5.99	6.16	7.02	7.13	4.33	3.89	8.77	5.11
650	5.61	5.79	6.47	6.59	4.59	4.62	8.16	4.42
700	5.21	5.40	5.86	6.00	4.77	5.34	7.68	3.64

Hatchery Study Site - Transect 4, Right Channel

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	20.11	19.58	22.59	22.02	8.89	7.45	30.38	19.70
250	14.28	13.96	15.07	14.77	8.59	6.83	23.06	13.02
300	10.65	10.43	11.12	10.91	8.33	6.80	17.05	8.38
350	7.73	7.59	8.46	8.33	7.41	7.11	12.32	4.93
400	5.88	5.79	6.67	6.56	6.49	7.35	9.40	2.83
450	5.02	4.96	5.81	5.72	5.98	7.46	7.65	1.72
500	4.02	3.98	4.72	4.65	4.97	6.66	6.35	1.05
550	3.34	3.31	3.79	3.74	4.23	6.04	5.61	0.65
600	2.98	2.95	3.27	3.23	3.75	5.42	5.18	0.43
650	2.56	2.55	2.70	2.68	3.13	4.31	4.71	0.29
700	2.31	2.30	2.34	2.33	2.73	3.65	4.45	0.20

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Hatchery Study Site - Transect 5

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	12.25	12.25	11.47	11.47	3.11	2.96	11.71	12.25
250	14.84	14.84	15.48	15.48	4.60	3.65	18.68	14.83
300	15.80	15.80	16.09	16.09	6.27	4.87	20.00	15.66
350	15.62	15.62	16.10	16.10	7.85	6.48	19.54	14.87
400	15.09	15.09	15.92	15.92	9.22	8.09	18.78	13.20
450	14.81	14.81	15.50	15.50	10.37	9.90	18.49	11.61
500	14.40	14.39	14.80	14.80	11.18	11.75	18.34	9.97
550	14.02	14.00	14.12	14.12	11.69	12.76	17.30	8.64
600	13.61	13.56	14.11	14.10	12.08	13.02	17.53	7.45
650	13.20	13.12	13.43	13.39	12.28	12.75	17.15	6.41
700	12.72	12.59	12.84	12.76	12.27	12.59	16.75	5.48

Big Bull Flat Study Site - Transect 1

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	31.62	33.86	27.56	30.30	24.75	20.08	28.37	26.13
250	38.55	41.03	35.29	38.16	32.51	27.06	34.12	27.78
300	43.23	45.78	44.16	46.88	38.18	35.67	40.46	27.82
350	45.99	48.42	47.80	50.38	41.91	42.04	47.76	26.74
400	46.83	49.04	46.94	49.40	44.03	45.07	50.55	24.68
450	46.92	48.86	45.86	48.21	45.35	45.67	49.82	22.23
500	47.08	48.76	46.16	48.34	46.16	45.94	49.18	19.15
550	47.03	48.42	47.27	49.16	46.51	47.95	47.12	16.39
600	46.69	47.76	48.49	49.95	45.99	49.11	48.47	14.31
650	46.24	47.06	47.90	48.95	44.91	51.26	48.37	12.03
700	45.39	45.97	47.27	47.97	43.84	51.45	48.06	10.34

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Big Bull Flat Study Site - Transect 2

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Dep
200	48.99	51.05	50.22	52.80	28.65	22.68	48.38	44.77
250	55.42	56.80	54.39	56.27	38.35	32.50	58.92	46.20
300	59.03	59.78	57.07	58.24	46.76	40.61	62.27	43.36
350	60.39	60.64	57.58	57.97	53.71	46.17	60.76	37.99
400	60.01	59.77	58.78	58.57	57.42	53.59	60.60	31.88
450	58.80	58.15	59.36	58.87	59.87	59.75	62.86	25.66
500	57.56	56.57	60.53	59.77	60.46	62.51	64.80	20.36
550	55.93	54.65	60.80	59.73	60.12	65.99	64.05	16.22
600	54.29	52.78	59.45	58.10	58.82	66.55	65.16	12.72
650	52.54	50.89	57.50	55.96	56.70	64.44	65.69	10.19
700	51.40	49.67	55.33	53.66	54.64	62.15	64.18	8.13

Big Bull Flat Study Site - Transect 3

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Dept
200	13.77	14.83	5.88	7.13	12.06	5.52	5.51	11.37
250	20.13	21.11	12.73	14.11	17.94	10.19	9.80	15.15
300	25.09	25.93	21.26	22.68	23.55	16.26	18.17	16.52
350	28.59	29.23	25.22	26.35	28.17	21.25	22.94	16.02
400	30.57	31.03	28.56	29.51	31.68	26.44	29.03	14.06
450	32.09	32.40	30.54	31.40	34.15	31.64	26.96	11.72
500	33.52	33.70	33.10	33.77	35.88	35.90	28.65	9.76
550	34.88	34.95	35.70	36.15	36.55	38.89	33.68	7.98
600	36.20	36.16	37.54	37.79	36.88	41.34	36.94	6.71
650	37.19	37.06	38.62	38.69	36.29	43.81	37.52	5.68
700	38.16	37.94	39.84	39.71	35.54	45.69	36.65	4.99

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Big Bull Flat Study Site - Transect 4, Left Channel

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	0.41	0.10	0.23	0.04	1.60	1.03	0.40	0.15
250	0.78	0.20	0.56	0.10	2.64	2.67	1.14	0.20
300	1.11	0.30	1.00	0.25	3.28	3.13	2.10	0.21
350	1.36	0.39	1.42	0.41	3.40	3.57	2.35	0.21
400	1.48	0.46	1.78	0.55	3.15	4.12	3.09	0.20
450	1.53	0.50	1.67	0.54	2.74	3.45	3.49	0.18
500	1.50	0.52	1.52	0.52	2.29	2.51	2.77	0.15

Big Bull Flat Study Site - Transect 4, Middle Channel

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	7.56	5.78	7.68	5.95	6.96	6.21	11.05	5.21
250	8.47	5.97	8.75	6.33	8.15	7.64	12.00	5.51
300	8.84	5.87	9.33	6.52	8.91	9.00	12.90	5.42
350	8.74	5.55	9.81	6.53	9.25	10.17	14.34	5.02
400	8.38	5.13	9.78	6.18	9.28	10.56	14.63	4.40
450	7.99	4.73	9.22	5.59	9.13	10.91	14.64	3.78
500	7.49	4.29	8.54	4.96	8.85	10.52	14.55	3.12
550	6.98	3.85	7.67	4.31	8.43	10.00	14.09	2.51
600	6.48	3.47	7.09	3.82	7.98	9.74	12.23	1.99
650	6.02	3.12	6.58	3.38	7.51	9.00	12.30	1.56
700	5.55	2.78	6.20	3.02	7.05	8.34	10.85	1.24

Big Bull Flat Study Site - Transect 4, Right Channel

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	28.77	28.77	23.21	23.21	17.71	10.46	13.07	24.92
250	36.91	36.91	34.63	34.63	26.72	20.92	24.77	27.71
300	43.58	43.50	41.60	41.59	35.55	29.61	36.21	27.55
350	48.44	48.31	46.63	46.59	43.20	37.97	38.52	24.92
400	52.29	52.10	52.19	52.12	49.38	46.20	43.99	21.54
450	54.78	54.53	56.29	56.21	53.62	52.02	51.80	17.95
500	56.32	56.03	58.57	58.47	56.04	56.78	54.88	14.63
550	57.07	56.72	60.29	60.17	56.78	60.87	55.96	11.80
600	57.29	56.89	61.90	61.77	56.60	63.41	57.60	9.61
650	57.04	56.59	63.35	63.18	55.41	65.16	59.61	7.87
700	56.21	55.71	63.80	63.54	53.55	66.76	61.32	6.57

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Big Bull Flat Study Site - Transect 5, Left Channel

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	5.26	5.26	3.90	3.90	1.04	0.97	2.39	5.26
250	6.95	6.95	7.39	7.39	1.75	1.60	7.09	6.95
300	7.29	7.29	8.11	8.11	2.19	1.94	8.80	7.29
350	7.21	7.21	7.17	7.17	2.36	2.12	8.86	7.17
400	6.89	6.89	7.69	7.69	2.39	1.93	8.58	6.76
450	6.35	6.35	6.38	6.38	2.41	1.90	8.59	6.16
500	5.57	5.57	5.14	5.14	2.39	1.78	6.34	5.36

Big Bull Flat Study Site - Transect 5, Middle Channel

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	2.76	5.94	3.03	6.56	7.90	7.98	7.84	1.49
250	2.49	5.55	3.03	6.60	8.30	9.63	7.87	0.94
300	2.34	5.27	2.91	6.36	8.23	10.38	7.99	0.68
350	2.57	5.48	2.59	5.91	7.97	10.35	8.25	0.92
400	3.16	6.09	2.43	5.65	7.68	9.59	8.80	1.57
450	4.01	7.03	3.07	6.41	7.46	8.85	9.49	2.50
500	5.49	8.65	3.90	7.47	7.36	8.51	10.25	4.06
550	7.14	10.42	6.29	9.82	7.49	8.77	11.26	5.82
600	9.07	12.43	9.39	13.12	7.79	9.04	15.04	7.84
650	10.80	14.13	11.07	14.69	8.31	9.17	16.56	9.65
700	12.21	15.44	13.24	16.71	8.98	9.59	18.47	11.12

Big Bull Flat Study Site - Transect 5, Right Channel

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	14.76	14.76	14.02	14.02	6.06	4.41	12.60	14.29
250	17.17	17.17	17.28	17.28	8.68	6.32	17.09	15.43
300	17.22	17.22	18.18	18.18	10.56	8.84	17.38	14.11
350	16.47	16.47	18.54	18.54	11.42	11.79	17.95	12.15
400	15.53	15.53	18.98	18.98	11.66	12.35	20.78	10.45
450	14.43	14.43	16.12	16.12	11.34	12.39	20.12	9.08
500	13.17	13.17	12.88	12.88	10.92	9.54	19.51	7.92
550	11.65	11.65	11.03	11.03	10.24	8.41	14.48	6.71
600	10.43	10.43	9.61	9.61	9.58	7.99	12.21	5.57
650	9.27	9.27	8.47	8.47	9.00	7.50	10.20	4.52
700	8.32	8.32	7.87	7.87	8.33	7.20	8.75	3.62

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Barnowl Riffle Study Site - Transect 1

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	7.61	10.72	8.20	11.56	9.04	8.96	16.90	6.51
250	6.42	9.31	6.98	10.19	8.58	8.63	14.26	4.85
300	5.89	8.44	5.90	8.62	7.85	8.38	13.16	4.23
350	5.67	7.90	5.74	8.13	7.06	7.25	11.43	4.17
400	5.58	7.48	6.52	8.52	6.37	6.79	11.68	4.26
450	4.97	6.58	5.81	7.60	5.75	6.31	10.78	3.89
500	4.18	5.62	4.56	6.24	5.16	6.09	8.78	3.22
550	3.77	5.11	3.41	4.97	4.73	5.45	8.01	2.81
600	3.93	5.14	3.70	5.06	4.42	4.81	6.60	2.94
650	4.52	5.56	4.32	5.48	4.35	4.54	6.16	3.57
700	5.05	5.99	5.32	6.37	4.50	4.61	6.34	4.26

Barnowl Riffle Study Site - Transect 2

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	15.92	18.03	17.24	19.65	20.76	22.82	25.33	6.96
250	16.33	18.12	18.23	20.55	20.67	23.98	27.36	6.79
300	16.63	18.07	18.37	20.28	19.43	24.19	28.07	7.49
350	16.41	17.56	18.33	19.66	18.02	22.01	28.39	7.92
400	16.07	16.95	17.66	18.46	16.75	21.05	24.77	7.95
450	15.60	16.25	17.19	17.70	15.80	19.28	24.25	7.52
500	14.91	15.32	16.17	16.53	14.93	18.18	22.42	6.87
550	14.21	14.38	15.04	15.25	14.24	16.78	20.01	6.05
600	13.38	13.31	14.08	14.08	13.58	15.89	17.46	5.27
650	12.54	12.31	13.30	13.18	12.90	14.65	16.26	4.55
700	11.63	11.27	12.50	12.24	12.15	14.19	14.06	3.81

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Red's Riffle Study Site - Transect 1

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	15.54	17.68	17.25	20.25	11.65	10.88	28.28	14.31
250	13.66	14.73	14.72	15.91	12.20	11.36	27.72	11.22
300	11.49	12.02	11.91	12.27	11.54	11.29	22.13	8.42
350	9.42	9.89	9.85	10.30	10.31	10.16	17.29	6.23
400	8.16	8.69	8.97	9.43	8.91	9.38	13.56	4.98
450	6.98	7.62	7.70	8.28	7.71	8.94	11.94	4.07
500	6.36	7.09	6.41	7.06	6.76	7.91	10.80	3.80
550	6.21	6.97	6.31	7.02	6.01	6.55	10.70	3.96
600	6.19	6.98	6.29	7.07	5.63	6.16	9.62	4.29
650	6.13	6.95	6.57	7.40	5.42	6.19	9.00	4.51
700	6.43	7.25	6.86	7.73	5.30	6.35	8.52	4.99

Red's Riffle Study Site - Transect 2

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	15.77	14.47	18.67	17.22	10.86	9.69	34.62	14.33
250	11.71	10.54	12.86	11.43	10.76	9.82	26.46	9.42
300	8.55	7.17	8.55	7.07	9.47	8.38	18.56	5.91
350	6.59	4.95	6.83	4.90	7.85	7.22	12.90	4.13
400	5.15	3.49	5.26	3.53	6.44	6.40	9.95	3.18
450	4.25	2.58	4.42	2.74	5.26	5.65	8.06	2.70
500	3.70	2.04	3.94	2.21	4.53	5.16	7.09	2.40
550	3.46	1.79	3.68	1.82	3.94	4.74	6.50	2.25
600	3.32	1.65	3.45	1.54	3.63	4.42	5.67	2.13
650	3.19	1.56	3.33	1.42	3.40	4.25	4.79	1.99
700	3.17	1.56	3.30	1.37	3.38	4.16	4.27	1.84

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Red's Riffle Study Site - Transect 3

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	10.41	13.17	13.08	16.29	7.74	7.31	18.36	10.23
250	7.75	9.41	8.60	10.58	6.91	6.47	18.91	7.32
300	4.80	5.65	4.59	5.53	5.49	5.43	10.39	4.10
350	3.13	3.48	2.50	2.97	4.01	4.02	5.10	2.35
400	2.11	2.20	1.92	2.01	2.94	3.18	3.95	1.46
450	1.68	1.58	1.61	1.51	2.23	2.68	2.87	1.20
500	1.61	1.36	1.53	1.17	1.82	2.27	2.28	1.23
550	1.66	1.32	1.63	1.01	1.59	1.85	2.59	1.29
600	1.66	1.34	1.53	0.95	1.55	1.51	2.15	1.25
650	1.60	1.34	1.37	0.93	1.56	1.30	2.04	1.14
700	1.55	1.36	1.07	0.85	1.57	1.09	2.06	1.01

Robinson Riffle Study Site - Transect 1

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	23.58	30.76	22.48	30.15	15.76	16.27	32.17	21.04
250	26.44	33.67	26.54	34.13	16.85	17.47	36.40	24.16
300	26.20	32.89	27.03	34.97	16.38	15.78	42.26	24.31
350	24.74	30.88	29.15	35.94	16.13	14.84	47.05	23.04
400	22.20	27.76	26.37	32.25	15.80	13.62	44.48	20.69
450	18.05	22.84	20.89	25.81	14.07	12.39	36.70	16.79
500	14.50	18.78	16.29	20.83	13.25	11.82	32.79	13.35
550	11.06	14.90	11.72	16.09	11.83	10.40	26.36	9.93
600	8.47	11.94	8.64	12.68	10.68	9.69	20.99	7.26
650	6.14	9.20	6.20	9.92	9.31	9.02	16.53	5.05
700	4.71	7.55	4.73	8.22	8.45	8.60	13.63	3.62

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Robinson Riffle Study Site - Transect 2

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Deptl
200	25.26	29.95	24.76	29.64	11.76	10.12	33.67	24.70
250	27.64	32.32	26.71	31.48	13.88	12.14	34.92	27.00
300	26.28	30.86	29.01	33.49	14.58	12.93	39.96	25.52
350	22.92	27.32	26.72	31.20	14.56	13.14	41.85	21.81
400	19.78	23.97	21.01	25.64	14.45	13.37	37.00	18.33
450	16.85	20.67	16.37	20.54	13.54	12.18	31.44	15.21
500	14.41	17.84	13.86	17.71	12.24	11.45	23.71	12.79
550	12.81	15.87	13.33	16.93	11.29	11.01	24.34	11.22
600	11.51	14.21	12.11	15.32	10.03	10.05	21.30	10.16
650	10.93	13.43	11.26	14.07	9.64	9.55	18.68	9.59
700	10.33	12.57	10.64	13.05	9.06	8.74	16.51	9.22

Robinson Riffle Study Site - Transect 3

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	8.50	18.87	6.51	17.50	12.59	11.98	21.75	8.50
250	12.73	23.93	9.53	21.02	15.04	13.92	25.69	12.73
300	16.32	28.06	14.35	26.32	17.28	16.68	29.96	16.20
350	19.50	31.36	18.66	31.58	19.18	18.77	34.85	19.08
400	21.47	32.95	23.25	36.21	20.32	19.92	42.23	20.79
450	22.27	32.84	23.98	36.74	20.57	20.64	46.02	21.36
500	21.43	30.77	23.25	34.69	19.98	19.51	47.97	20.44
550	20.69	28.99	23.74	33.58	19.99	19.12	47.07	19.64
600	19.05	26.17	21.78	30.06	19.21	18.25	42.64	17.95
650	16.69	22.60	19.01	25.72	17.57	16.51	38.70	15.59
700	14.61	19.49	17.12	22.45	16.07	15.29	34.02	13.46

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Robinson Riffle Study Site - Transect 4

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	54.74	58.51	57.50	61.25	31.62	27.34	59.19	46.28
250	55.67	59.77	64.81	68.91	36.27	34.94	69.02	44.86
300	50.90	54.97	60.30	64.38	37.28	38.68	71.60	39.43
350	44.16	48.02	51.38	55.32	36.07	37.77	70.55	32.83
400	36.87	40.38	40.29	43.95	33.35	32.26	62.13	26.38
450	30.59	33.70	32.26	35.53	29.92	29.03	47.62	21.19
500	25.84	28.54	26.25	29.06	27.10	25.86	40.40	17.19
550	22.35	24.80	22.28	24.77	24.82	22.53	33.94	14.10
600	19.36	21.59	19.65	21.83	22.34	20.78	28.03	11.73
650	17.05	19.17	17.62	19.63	20.58	19.70	25.40	9.88
700	15.15	17.18	16.21	18.19	19.10	18.90	22.88	8.37

Robinson Riffle Study Site - Transect 5

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	61.50	68.80	62.11	70.02	34.09	29.50	57.86	55.27
250	77.46	85.73	82.12	90.97	47.05	40.06	87.84	66.30
300	85.24	93.74	90.67	99.73	57.08	48.50	102.10	69.75
350	86.31	94.64	92.87	102.07	64.73	58.12	104.69	66.56
400	81.28	89.12	92.93	101.77	67.02	66.15	107.40	58.89
450	74.13	81.34	89.03	97.24	66.85	71.66	109.14	49.40
500	65.45	71.92	79.16	86.56	63.59	71.20	106.69	40.12
550	57.15	62.89	67.03	73.78	59.34	66.36	99.96	31.97
600	48.73	53.71	55.87	61.94	52.94	59.27	89.42	25.30
650	41.62	45.94	46.94	52.16	46.97	55.19	73.81	20.23
700	35.54	39.26	38.33	42.67	41.33	49.52	65.96	16.32

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Robinson Riffle Study Site - Transect 6

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	55.24	56.51	52.43	54.13	33.86	30.09	51.01	46.82
250	71.11	70.90	67.89	67.99	43.88	39.23	64.43	58.44
300	84.42	82.40	86.85	85.67	52.35	48.06	84.70	67.64
350	94.85	91.07	100.54	96.58	59.72	57.28	103.29	74.25
400	98.64	93.25	108.07	103.01	63.84	65.50	113.27	75.93
450	96.91	90.40	111.74	105.65	65.42	70.80	126.90	72.81
500	91.39	84.39	108.51	100.57	65.78	70.20	135.23	65.86
550	83.93	76.96	97.30	89.04	64.98	69.49	132.01	56.93
600	74.72	68.21	85.15	77.56	61.90	66.91	123.69	47.27
650	64.57	58.75	74.38	67.29	56.88	63.01	108.17	38.13
700	56.91	51.77	65.75	59.51	53.13	61.99	95.30	30.17

Sodbuster Riffle Study Site - Transect 1

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	15.55	17.28	16.33	18.48	14.76	14.96	24.07	12.58
250	15.73	16.07	16.81	17.11	15.61	15.57	25.94	12.33
300	14.55	14.30	16.02	15.95	15.47	16.06	23.65	10.65
350	12.95	12.55	14.91	14.52	14.89	16.06	22.64	8.36
400	11.51	11.10	13.27	12.66	13.65	16.66	21.22	6.51
450	10.61	10.27	12.01	11.41	12.38	15.64	20.85	5.52
500	10.20	9.99	11.24	10.69	11.12	13.76	18.95	5.49
550	10.28	10.19	10.51	10.18	10.12	12.41	17.06	6.00
600	10.49	10.52	10.80	10.75	9.39	11.19	15.22	6.72
650	11.26	11.42	11.07	11.26	9.06	9.87	14.29	7.72
700	12.03	12.26	13.42	13.72	9.02	9.72	15.49	8.62

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Sodbuster Riffle Study Site - Transect 2

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Depth
200	22.14	14.23	23.44	14.68	15.96	15.40	33.20	16.89
250	19.00	11.96	19.85	12.10	15.49	15.13	29.93	13.14
300	17.00	10.83	18.76	11.73	15.31	15.94	27.77	10.25
350	17.17	11.78	18.27	12.03	15.04	16.97	28.48	9.70
400	18.78	14.28	17.66	12.26	15.06	17.05	27.23	10.93
450	19.85	16.07	18.71	14.23	15.32	17.21	28.23	11.91
500	21.21	17.83	20.09	16.65	15.72	18.08	30.06	13.25
550	22.89	19.66	23.28	19.96	15.72	17.65	35.62	15.07
600	24.13	20.68	24.97	21.74	15.94	17.26	38.76	16.54
650	24.81	20.96	25.81	21.73	16.40	17.38	42.60	17.45
700	24.69	20.41	24.50	20.09	16.52	17.81	38.65	17.55

Sodbuster Riffle Study Site - Transect 3

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Dept
200	17.79	17.89	19.26	19.35	11.53	11.31	26.83	13.73
250	19.93	20.00	18.95	19.12	12.82	12.51	27.20	14.60
300	24.93	25.24	21.64	21.72	14.17	14.31	27.63	18.55
350	28.93	29.41	27.16	27.33	16.15	17.22	32.90	22.05
400	32.29	32.90	32.54	33.12	17.38	19.54	39.99	25.22
450	34.54	35.25	38.19	38.87	18.34	19.73	50.31	27.58
500	35.47	36.12	39.39	40.17	19.29	19.18	56.76	28.71
550	34.67	35.08	36.29	36.82	20.12	19.03	51.57	27.92
600	33.45	33.49	33.61	33.92	20.89	19.16	45.16	26.41
650	32.19	31.74	32.11	31.97	21.40	19.81	39.76	24.42
700	31.85	30.77	31.18	30.61	21.93	20.74	35.84	23.13

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Bullfrog Riffles Study Site - Transect 1

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Dep
200	10.72	11.18	11.01	11.95	7.67	6.23	22.32	10.03
250	9.77	8.73	8.57	8.00	7.58	6.51	16.61	8.58
300	9.42	7.48	8.68	6.47	7.20	6.81	14.20	8.02
350	10.34	7.89	9.23	6.79	6.69	6.57	13.98	8.97
400	11.96	9.36	11.02	7.83	6.68	6.45	16.53	10.77
450	13.73	11.34	14.55	11.75	6.85	6.71	19.18	12.71
500	15.66	13.53	15.02	12.66	7.33	7.26	17.78	14.80
550	17.26	15.21	18.19	16.27	7.89	8.02	21.77	16.37
600	18.43	16.34	18.85	17.30	8.73	8.46	23.31	17.27
650	18.91	16.71	20.04	18.18	9.56	9.46	22.57	17.38
700	18.97	16.43	21.80	19.61	10.15	10.78	24.89	16.99

Bullfrog Riffles Study Site - Transect 2

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Dept
200	27.66	26.30	27.59	27.80	20.81	19.79	35.54	25.00
250	31.08	26.57	31.73	28.30	24.39	23.24	42.08	25.31
300	32.76	25.85	35.58	28.89	26.08	27.20	44.12	24.34
350	33.90	25.28	37.10	27.57	26.23	29.89	48.18	23.85
400	33.98	24.60	39.52	27.65	25.72	28.26	55.66	23.51
450	33.09	23.91	37.10	25.92	24.77	25.54	55.07	22.99
500	31.33	22.98	33.66	24.51	23.64	23.99	50.55	21.98
550	29.18	21.99	30.82	23.28	22.44	21.59	44.61	20.44
600	27.29	21.19	29.00	22.47	21.50	20.28	38.31	18.68
650	25.42	20.30	27.56	21.87	20.66	20.26	35.66	16.91
700	23.78	19.53	25.59	20.64	19.87	20.70	33.64	15.16

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).

Bullfrog Riffles Study Site - Transect 3

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original De
200	4.59	8.46	3.20	7.72	7.58	8.18	12.81	4.51
250	6.55	9.65	4.49	8.16	7.93	8.82	11.81	6.32
300	10.45	12.46	7.89	10.60	7.97	8.77	12.11	10.12
350	14.81	15.37	11.28	12.84	8.38	8.49	18.02	14.47
400	18.08	17.10	15.29	15.11	9.61	8.98	20.68	17.79
450	21.12	18.56	18.79	16.41	10.63	9.58	22.55	20.84
500	23.22	19.31	22.97	19.19	12.05	10.16	26.80	22.70
550	23.86	19.16	25.58	20.10	13.59	11.26	34.35	22.76
600	23.02	18.17	22.67	17.40	15.14	12.25	32.75	21.00
650	21.88	17.16	20.69	15.74	16.55	13.87	30.05	18.60
700	20.76	16.32	19.56	15.03	17.68	15.61	27.46	15.83

Bullfrog Riffles Study Site - Transect 4

Flow	Merced Smoothed Tail	Merced Smoothed Head	Merced Nonpar Tail	Merced Nonpar Head	Stanislaus Smoothed	Stanislaus Nonpar	Tuolumne	Merced Original Dep
200	24.51	29.15	26.57	32.12	26.63	28.27	32.99	15.84
250	23.42	27.27	27.14	31.57	25.34	29.28	37.28	13.95
300	21.59	24.60	24.45	28.04	22.20	25.84	35.10	12.97
350	19.60	21.84	20.78	23.25	18.99	20.75	32.06	12.45
400	17.94	19.64	18.54	20.37	16.17	15.97	26.84	12.13
450	16.85	18.05	17.06	18.51	14.16	14.46	22.09	12.06
500	16.49	17.19	16.77	17.77	12.61	14.10	20.50	12.38
550	16.80	17.07	16.78	17.37	11.55	12.71	21.07	13.09
600	17.51	17.38	16.59	16.88	10.94	11.62	20.01	14.19
650	18.33	17.88	18.27	18.05	10.65	11.04	21.16	15.33
700	18.97	18.17	19.81	19.25	10.49	10.59	21.84	16.27

Data in above tables are Weighted Useable Area (1000 square feet per 1000 feet of stream) for each criteria set in Appendix D. Flow is main-channel discharge at that site (cfs).